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Technical Report

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B-1 SYSTEMS APPROACH TO TRAINING
TECHNICAL MEMORANDUM SAT-1

FINAL REPORT

VOLUME 1

Calspan Report No. FE-5558-N-1

JULY 1975

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In support of the B-1 System Program Office, this ~~analytic~~ analysis study developed recommended and alternative training systems for the future B-1 ~~air vehicle~~ bomber. The training system provides for transition, recurring, and upgrade training for the four positions of the aircrew: pilot, copilot, offensive systems operator, and defensive systems operator. The instructional system development (ISD) is enhanced by the concurrent development of two computer aids. These are: (1) Sorting Model, which allows efficient storage,

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20. (Continued.)

retrieval, collating, and updating of mission/function/task analysis and supporting data; and (2) Training Resources Analytic Model (TRAM), which provides time-phased costs and resource requirements for the training system over the B-1 life cycle.

A major goal of the ISD was to increase training cost-effectiveness by eliminating unnecessary training and overly elaborate training devices while training the aircrew to the performance criteria. The approach to providing instructional system designs was based on factors including:

1. Statements of behavioral objectives
2. Current and projected simulation state-of-the-art
3. Modern educational technology techniques (methods and media)
4. External influences, such as airspace availability, aircrew and support personnel sources and training rates, force structure (number and geographic distribution of aircraft)
5. Trade-off and sensitivity analyses (using the TRAM) of such factors as ratio of airborne to ground-based training hours, centralization of training facilities, ratio of hours in various training media, and training media time phasing.

The outputs for this program are descriptions of the recommended and alternative training systems, complete with a syllabus for each course, descriptions of required media and facilities, costs, and schedules.

JULY 1975
SAT-1
VOL. 1

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Many military and civilian personnel contributed generously of their time and talents in the process of Calspan's numerous data collection trips. Their names and organizations are noted in Volume 3, which is Appendix B of this report. In addition, these several individuals spent long hours in various aspects of creating the task analysis data base provided to our effort:

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R.C. Sugarman
S.L. Johnson
W.F.H. Ring

PREFACE

This document is one of several technical memoranda which have been delivered to the B-1 Systems Project Office (B-1 SPO) in performance of the Systems Approach to Training (SAT) Task under Contract Number F33657-75-C-0021. Each of the separate SAT documents is listed below. Additional copies may be requested from: B-1 Systems Project Office, Data Configuration Division, Wright-Patterson Air Force Base, Ohio.

Technical Memoranda	Number	Author(s)	Date
B-1 Systems Approach to Training, Final Report.	SAT- 1 Vol. 1	R. Sugarman S. Johnson W. Ring	July 1975
B-1 Systems Approach to Training, Final Report. Appendix A: Cost Details.	SAT- 1 Vol. 2	H. Reif W. Ring	July 1975
B-1 Systems Approach to Training, Final Report. Appendix B: Bibliography and Data Collection Trips.	SAT- 1 Vol. 3	A. Blair	July 1975
Behavioral Objectives for the Pilot, Copilot, and Offensive Systems Operator.	SAT- 2 Vol. 1 & 2	J. Mitchell W. Hinton S. Johnson	July 1975
Simulation Technology Assessment Report (STAR).	SAT- 3	S. Johnson J. Knight R. Sugarman	July 1975
Sorting Model for B-1 Aircrew Training Data. User's and Programmer's Guide.	SAT- 4	J. Menig T. Ranney	July 1975
Training Resources Analytic Model (TRAM). User's Manual.	SAT- 5	W. Ring G. Gaidasz J. Menig W. Stortz	July 1975
Training Resources Analytic Model (TRAM). Programmer's Manual.	SAT- 6	W. Ring G. Gaidasz J. Menig W. Stortz	July 1975
Task Analysis Listings.	SAT- 7	J. Mitchell T. Ranney	July 1975
Control/Display Catalog and Action Verb Thesaurus.	SAT- 8	T. Ranney A. Blair	July 1975

JULY 1975
SAT-1
VOLUME 1

B-1 SYSTEMS APPROACH TO TRAINING*

Robert C. Sugarman
Steven L. Johnson
William F.H. Ring

EXECUTIVE SUMMARY

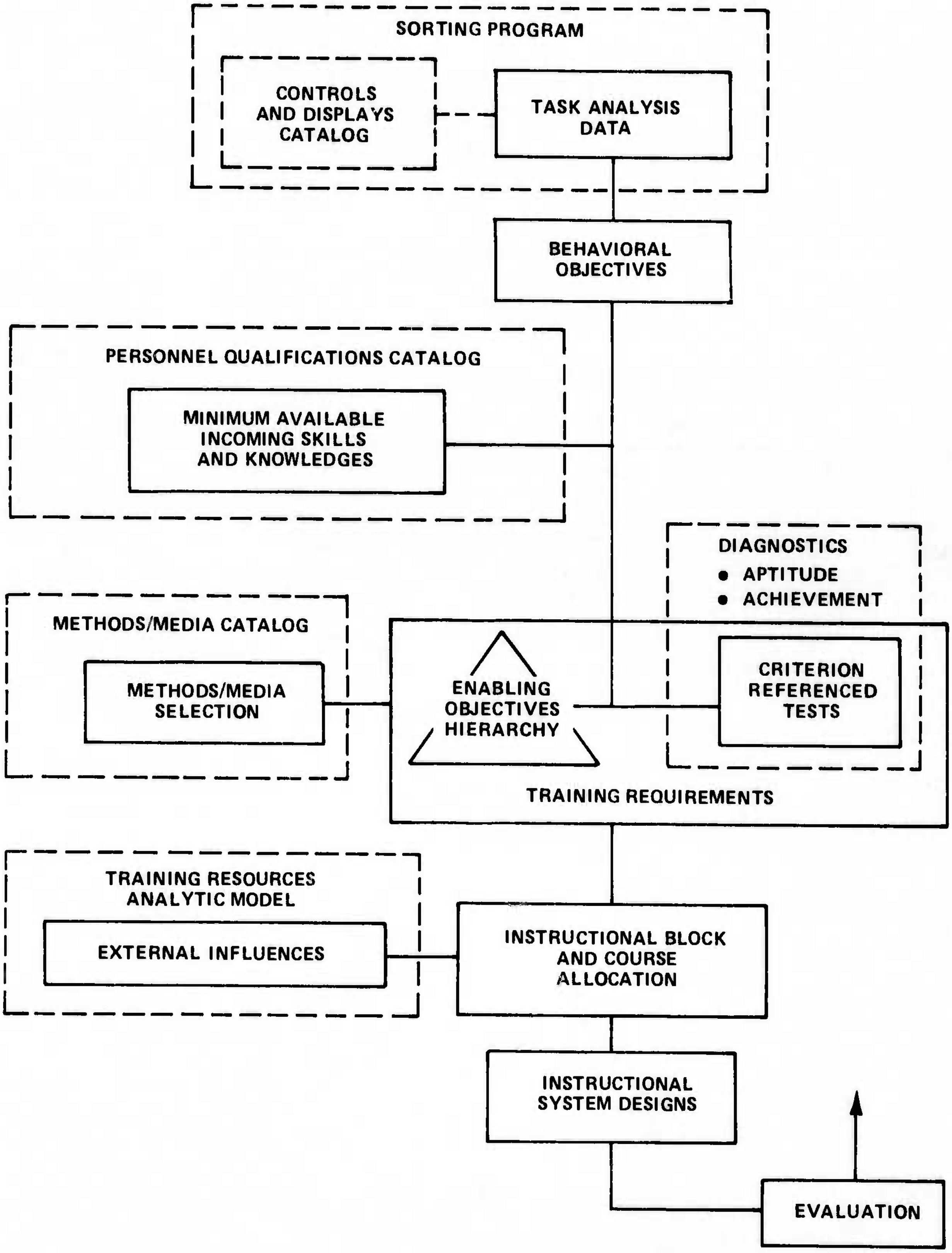
The SAT Approach

Instructional System Development (ISD) is a structured process for designing a training system. The Systems Approach to Training (SAT) applies the techniques of systems analysis to ISD in order to more fully ensure that the entire training system is considered, including interactions with time and external constraints. SAT has now been applied to the development of the syllabi for the aircrew of the B-1 strategic bomber. This program was the first attempt to carry out such an analysis for an Air Force weapon system not yet in the operational inventory.

SAT, as implemented in this program, is a conceptual framework rather than a rigid set of steps. Before embarking on the B-1 aircrew SAT program, an information flow, summarized in the following Figure, was conceptualized to define the scope of the training system and to enter the appropriate data (shown by dashed lines) into and around the ISD steps. Each block in the Figure can be expanded into sets of data that describe it and relationships that tie the data together. The extent to which the data exist (or are reliable and valid) and the extent to which the relationships are known set some of the limitations to the potential success of a SAT study. The initial source of information is the Task Analysis data base, the quality of which establishes the potential quality of the overall instructional system. In addition, a Controls and Displays Catalogue was developed that contains all the system's controls and displays which are acted upon in the course of the mission. By combining the two data bases in a computerized Sorting Program, control and display utilization was grouped across the mission to determine when and how each control and display is used. Such information impacts on the development of instruction.

In the next phase, Behavioral Objectives were developed which delineate the "who, what, how, when and how well" of each definable behavior required to perform the mission. In the process of writing these objectives, a "first cut " was made at the selection of training tasks to eliminate any behaviors which should not appear as training objectives (e.g., behaviors which can be assumed to be in the entering repertoire of all trainees or

* The data reported in this document reflect the latest calculations and may, therefore deviate somewhat from data released prior to 10 October 1975.



SYSTEMS APPROACH TO TRAINING

which can be delegated to on-the-job training or job performance aids). Included in the objectives are such things as criticality/difficulty/frequency information, specific crew coordination requirements, and a detailed listing of the supporting behaviors (enabling objectives) in which proficiency is a prerequisite to training of the behavior.

The process of selecting tasks for training is continued in the consideration of the Personnel Qualifications, where the trainees may have a wide variation in their available incoming skills and knowledges. The Behavioral Objectives that are not in the incoming trainee's repertoire (arranged in a hierarchy of learning sequence) and the performance standards which the trainee is to demonstrate comprise the Training Requirements.

Existing knowledge of psychological learning principles and educational methods and media are combined in the Methods/Media Selection process. This process is applied to logical groupings of enabling and behavioral objectives to determine the educational strategies and media which will provide the optimum training environments for these groupings. The resulting listing of applicable media and educational strategies are used as inputs to Instructional Blocks and Courses, and as alternatives to be optimized in the Training Resources Analytic Model (TRAM) under the many constraints of the External Influences, such as costs, training equipment available, number of personnel required in each speciality to support the system, and so forth.

The application of the TRAM to the hypothesized course design allowed the preferred Instructional System Design to be selected on the basis of documentable criteria, notably time and cost factors. The process of Evaluation, while indicated by only a small block in the Figure, is actually a large effort consisting of courseware development, validation of the courseware, feedback of the findings to all relevant points in the design development process, and successive "fine tuning" until the trainees are being taught the behaviors required to carry out their mission, and only those behaviors, with the minimum usage of training resources.

This SAT process, if applied by a suitable team of analysts, can provide a number of benefits:

orderliness -- Each set of data required by the analysis is called out in the schema of the Figure (more precisely, as subsets of those blocks in an elaborated version). A Specialist can then be assigned to carry out the information gathering and/or decision making as indicated.

completeness -- Each element of the system that impacts on the decision process is delineated.

relevance -- The SAT process starts with job performance requirements in the form of a task analysis: each succeeding decision is traceable back to those requirements.

economy -- Systems analytic techniques make possible the optimization of alternatives with respect to cost and time, aided by sensitivity analyses of critical variables.

documentation -- The sets of data (blocks in the Figure) provide the rationale for each necessary decision; each decision becomes a data point in its own right to support subsequent blocks. Documentable data, therefore, include descriptive facts, research results, assumptions, decisions and constraints.

evaluation -- Invalid data (facts, decisions, etc.) are brought to light through feedback from training system outputs.

Program Objectives

This study has defined the training system for B-1 aircrew members, including:

1. Transition -- personnel from a variety of sources, differing in relevant training and experience, are trained for an assignment to a B-1 crew position;

2. Upgrade -- A B-1 crew member is trained for a more demanding B-1 assignment; specifically copilot to pilot; and,

3. Recurring -- periodic proficiency training to maintain combat readiness.

The study also formulated the basic course structure for such training. Developed were:

1. Behavioral (enabling and criterion) objectives;

2. A syllabus for each course;

3. A review of the state-of-the-art in the engineering and behavioral aspects of training devices;

4. The total mix of instructional equipment required to support aircrew training courses;

5. Functional descriptions of recommended training devices;

6. Time-phased trainee flow requirements;

7. Facilities required;

8. Instructors and support personnel required;

9. Time-phased costs and utilization of training resources;

10. A Sorting Program to employ computer capability in the storage, collating, and updating of the task analysis data base; and,

11. A Training Resources Analytic Model (TRAM) to carry out computer simulations and evaluations of the proposed training systems and alternatives based on B-1 deployment factors, resource availability, costs, trainee sources, attrition rates, and a variety of other variables. This model is used to generate many of the other outputs listed.

Included in this analysis are the crew positions of Pilot, Copilot, and Offensive Systems Operator. The task analysis for the Defensive Systems Operator (DSO) was not ready for delivery to Calspan to be incorporated into this SAT analysis. Some rudimentary assumptions were made regarding the DSO training requirements so that a preliminary estimate of the impact of the DSO syllabus could be calculated.

Program Guidelines

Every attempt was made to ensure that this analysis was responsive to the needs of the B-1 SPO and the Strategic Air Command. To that end many of the parameter values were taken from the latest B-1 Concept of Employment, the latest maintenance concept (centralized facilities), and specific direction from the project technical officer and his SAC consultants (from the 509th Bomb Wing, Pease AFB, and the 4200th Test and Evaluation Squadron, Edwards AFB). Much weight was given to the FB-111 CCTS (Combat Crew Training School) experience, as related by their personnel to Calspan's analysts. It was assumed that the total number of operational B-1 air vehicles will be 210; the CCTS will be centralized; and trainee sources are expected to be as follows; follows;

B-1 Pilots from B-1 Copilot upgrades, FB-111 Pilots, B-52 Pilots KC-135 Pilots
B-1 Copilots from B-52 Copilots, KC-135 Copilots, UPT (Undergraduate Pilot Training)
B-1 OSO from FB-111 R/N, B-52 R/N, UNT (Undergraduate Navigator Training)
B-1 DSO from B-52 EWO, EWOT (Electronic Warfare Officer Training).

In general, attrition is assumed to be 0.3 per year with an additional 0.2 due to copilots upgrading to pilots. The latest air vehicle delivery schedule was

used to generate the time-phased requirements for the graduation of qualified crews.

In addition to the assumptions regarding the values of the above parameters, the SAT analysts selected a number of instructional strategies as appropriate for the B-1 aircrew training system. Significant among them are:

1. Base new skill/knowledge on earlier training.

2. Early start on training needing the most practice.

3. Organize by "systems integrated with phase of flight."

4. Active trainee participation preferred.

5. Early "hands-on".

6. Self-paced instruction preferred.

7. Use simplest (least costly) applicable device.

The use of these strategies in combination with the other assumptions and the general methodology of the systems approach, allowed the analysts to specify the most economical training system that will achieve all of the training objectives. The expenditure of more funds would not achieve significantly greater effectiveness with respect to satisfying those objectives and the expenditure of less would result in the compromising of objectives.

Instructional Devices

Through an iterative process involving the interplay of the training objectives, the instructional strategies, the state-of-the-art in simulation, and subject-matter-expert opinion, a set of training media were defined and refined for the B-1 instructional system. A significant difference exists in both cost and capability between any two devices of the set. Because of ambiguities in names, the devices are referred to by designated number. However in the summary to follow, descriptive names are offered for ease of assimilation of the information.

Device 0; General Purpose Carrel (All Crew Members) The simplest, and least costly device is what is generally referred to as a general purpose carrel. This device includes an audio-visual presentation, workspace for writing, and a photographic representation of the cockpit layout. The purpose of this device is for individualized instruction of material that does not involve active manipulation or monitoring of controls and displays by the trainee.

Device 1; Familiarization Trainer (Pilot/Copilot) The next level of complexity that is required on the basis of training objectives is used to familiarize the pilot and copilot trainees with the location and operation of cockpit controls and displays. Device 1 incorporates an audio-visual presentation. In addition, the controls and displays are replicas of the operational equipment, with exact location and approximate control "feel," but with low dynamic fidelity.

Device 2/P/CP, 2/OSO, and 2/DSO: Procedures Trainers Device 2 is used to practice procedures that require complex interactions between the trainee and the equipment and among the various components of the equipment. There are three devices that are used for this purpose, one for the front station (pilot and copilot), one for the OSO and one for the DSO. These devices provide total interactiveness between controls and displays in terms of normal and emergency procedure operations. Because maneuvers are not practiced in these devices,flight equation calculations are not incorporated in these trainers. A mini-computer controls both the trainer instrumentation and the sequencing of an audio-visual presentation that involves branched instruction logic on the basis of automatic performance measurement. These devices include pre-programmed malfunctions during procedures as well as online malfunction inputs by instructor personnel.

Device 3/P/CP; Part-Mission Trainer (Pilot/Copilot) The phases of flight that require an extensive amount of pilot and copilot practice in perceptual-motor tasks are take-off, refueling, manual terrain following, and landing. Device Number 3/P/CP is configured for the training of the objectives relating to these flight phases. This device has air vehicle replica controls and displays that respond with high fidelity. The training objectives instructed within this device involve precise motor control that requires cueing from both bodily motion and an external scene representation. For these purposes, a three degree-of-freedom motion base (roll, pitch, heave) and a night/dusk visual scene simulation (point-lights) are recommended for this device. Non-interactive FLIR tasks are practiced using a "canned " but dynamic FLIR presentation. Interactive FLIR is practiced during airborne training at no significant increase in flying time. A dynamic, interactive TFR is included for practice using this primary system.

Device 3/OSO; Part-Mission Trainer (OSO) The primary phases-of-flight in which high-fidelity, real time, interactive training device capability is required for OSO training objectives are high-level navigation, low-level navigation, aerial refueling, high and low level weapons delivery, bomb damage assessment, terrain following, and instrument landing approaches. The training objectives concerned with these flight phases require high fidelity landmass, navigation systems, and weapons delivery simulation. Digital Radar landmass (DRLM) is the technique required to meet the landmass requirements. As with Device 3P/CP, a "carrel" FLIR presentation is included. The calibration capabilities of Device 3/OSO are sufficient to do evaluative scoring of OSO trainees for the above-listed activities. A term that is often applied to

devices with similar capabilities is "avionics trainer."

Device 3/DSO; Part-Mission Trainer (DSO) This device is an electronic warfare simulation used for training the Defensive Systems Operator (DSO) on real-time ECM tasks. The primary components of this device are various data input (and acquisition) keyboards, frequency spectrum display, threat situation display, alphanumeric display, and a cursor control. As with Device 2/DSO, a detailed description of this device is dependent upon the conduction of an analysis of the DSO tasks, but it is expected that realistic programmed scenarios with responsive countermeasures would be included.

Device 4; Full-Mission Trainer This device is a total-crew trainer that provides crew coordinated practice of the EWO mission. The OSO and DSO stations of this device are the same as Devices 3/OSO and 3/DSO, with the addition of an electronic/software interface between the trainers to provide crew interaction capabilities. The front station (pilot and copilot) of this device is similar to the Device 3/P/CP, with the addition of the systems not included in the previously described device (e.g., weapons systems) that require the interface with the OSO and DSO stations. This device an be utilized both in an integrated-crew mode or a crewmember-independent mode (e.g., OSO and DSO, practicing interactively with the front station being totally independent). As with the component devices, this trainer incorporates automatic performance measurement, performance record and playback, and pre-programmed mission capabilities. The instructor can be at a console inside the cockpit during early training or outside during later, when he may be able to monitor more than one device.

Preferred Instructional System

All devices incorporate automated performance measurement as an instructional aid to the trainee and instructor. Computer Managed Instruction (CMI) is recommended for evaluation and planning at both the trainee and curriculum levels.

Combat Crew Training School (CCTS) uses the following concepts. Students enter CCTS on an individual basis (i.e. not in classes) with starting dates selected to provide the necessary qualified crews to man a particular B-1 becoming available. Each student will follow a track which best matches his prior training and experience. Each track is a series of instructional blocks which are described by their nominal duration, instructional objective, and the medium by which they are presented. Typically, an instructional block is one to four hours long and uses only one training medium. The next chart summarizes for each track the hours spent in each medium including Devices 0, 1,2,3, and 4, briefings, and B-1 utilization.

CCTS SUMMARY TABLE OF COURSE DURATIONS (HOURS) BY TRAINING DEVICE

COURSE	PILOT			CO-PILOT		OSO			DSO[2]	
TRACK[1]	A	B	C	D	E	F	G	H	I	J
DEVICE										
BRIEFING	89	96	108	96	96	76	81	89	97	107
0 – CARREL	43	40	68	40	68	78	84	110	50	60
1 – FAMILIARIZATION	31	43	48	43	48					
2 – PROCEDURES	36[3]	40[3]	40[3]	40[3]	40[3]	81	84	86	40	50
3 – PART-MISSION	29	37	48	37	37	24	35	50	50	65
4 – FULL-MISSION	21	21	21	21	21	21	21	21	21	21
B1	27	27	33	27	27	21	21	21	21	21
TOTAL	276	304	366	304	337	301	326	377	279	324

[1]TYPICAL SOURCE OF TRAINEES

[2]PRELIMINARY ESTIMATES ONLY

[3]INCLUDES 2 HOURS IN DEVICE 2/OSO

The recommended Proficiency Maintenance Training (PMT) course requires each Main Operating Base (MOB) to be fully equipped with all devices (including air vehicles) needed to maintain combat readiness. For each crew member, this training requires:

8 hrs - Device 0
6 hrs - Device 2 (1-hour sessions)
6 hrs - Device 3 (2-hour sessions)
6 hrs - Device 4 (one 2-hour and one 4-hour session.), plus one 5-hr training flight.

The economic analysis of the recommended instructional system assumed:

1) a single CCTS (as described above)
2) PMT at each MOB (as described above)
3) 6 MOB (30 UE) and 1 MOB (15 UE) co-located at the CCTS (additional 15 UE); total of 210 air vehicles to be manned
4) crew ratio of 2.0

5) attrition ratio of 30% per year (50% for copilots due to upgrade)
6) alert rate assumed to be 0.6 for the purposes of analysis
7) trainee sources prioritized among projected availability

The numbers of each device to support the recommended system are:

	CCTS [With co-located MOB (15 UE)]	MOB (30 UE)
0 - carrel	13	8
1 - familiarization	4	0
2 - procedures		
P/C	2	1
OSO	3	1
DSO	2	1
3 - part-mission		
P/C	2	1
OSO	2	1
DSO	2	1
4 - full-mission	2	1

Life-cycle costs were computed for the 10-year period starting in 1980, plus the RDT&E and acquisition costs to be expected before 1980. The costs for the recommended B-1 Aircrew training system are detailed in Appendix A (Volume 2).

<u>Alternative Considerations</u>

Parametric sensitivity studies were carried out for several alternative considerations, the most important of which are PMT concepts, crew ratio, and basing configurations.

<u>PMT Concepts</u>. In addition to the recommended PMT concept, three alternatives were considered:

a) Same as recommended, but two training flights totaling 8 hours (to correspond to the current operational concept);

b) Part and Full-Mission Trainers located only at a centralized base (with increases necessary in the time in those devices and in airborne time);

c) Airborne training in lieu of any training in Part or Full-Mission Trainers (increased airborne time, but reduced capability for the practice of dangerous/critical tasks)

Although the initial costs are reduced by about 12% for case "b" and by about 70% for case "c," the life-cycle costs are about 30% higher for case "a," about 45% higher for "b," and about 75% higher for case "c." The prime "cost driver" in these calculations is the airborne training time required.

Crew Ratio. The crew ratio parameter was systematically varied from the baseline case of 2.0 down to 1.0. Over the 10 year life-cycle, the total number of crews trained is directly proportional to the crew ratio (i.e. half as many crews when the ratio is 1.0). The corresponding total system cost at a crew ratio of 1.0 is about two-thirds of the total cost at a ratio of 2.0.

Basing Configurations. A variety of MOB configurations were investigated ranging from 5 MOB to 13 MOB, using initial investment as the most sensitive indicator of differences among configurations. The range of variation in initial investment costs was determined to be only 9%. By judicious use of the economies that are obtainable using the PMT variations (in centralization), it would be expected that the variation in cost can be kept within the same range for any other basing configuration.

Conclusions

This study represents the most comprehensive and thoroughly documented analysis of its kind ever undertaken for an Air Force training system. Among the important general findings and accomplishments resulting from the program are the following:

1. The equipment state-of-the-art is not exceeded in any of the training device requirements.

2. By selecting a spectrum of training devices that differ from each other in capability and corresponding cost, the ground-based training has been optimized, while the use of airborne training has been minimized.

3. Economic modeling techniques indicate that the total system costs are sensitive to crew ratio and PMT centralization concepts, while basing configurations are relatively insensitive.

4. A B-1 aircrew training program is recommended that meets rigorously documented training requirements, and accomplishes that at least cost.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

LIST OF FIGURES

LIST OF TABLES

Section I

INTRODUCTION

1.1 OBJECTIVE

The problem of determining the information a person must be taught in order to perform his assigned duties adequately has plagued training specialists since the beginning of formal instruction. Only recently has a methodology evolved that utilizes the techniques of systems analysis to assure pertinency and completeness. This methodology, termed a Systems Approach to Training (SAT), has had a definite impact on both civilian and military training programs. The terms Instructional System Development (ISD) and SAT are often used synonymously, although there is a distinction made between the two terms in this program. The definition of ISD, as given by Air Force Manuals 50-2 (1970) and 50-58 (1974) is:

> "A deliberate and orderly process for planning and developing instructional programs which insure that personnel are taught the knowledges, skills, and attitudes essential for successful job performance." (p. 1-1)

SAT applies the techniques of systems analysis to ISD in order to more fully ensure that the entire training system is considered, including interactions with time and external constraints. A major feature of SAT is a simulation model, the Training Resources Analytic Model (TRAM), which is used to evaluate alternative training systems with respect to itemized and total cost, time phasing of trainee graduation, and time phasing of resource requirements.

In the B-1 SAT task, AFM 50-2 Instructional Systems Development (1970) was taken as the point of departure for a comprehensive study of factors involved in the concept of Instructional System Development (ISD). In this analytical study, Calspan enlarged upon the established ISD process by:

1. conducting a review of all pertinent past and current research;

2. conducting a current and predicted state-of-the-art review of flight and systems simulation;

3. developing a Sorting Program to allow for the computer storage, retrieval, and updating of the task analysis data base;

4. developing a Training Resources Analytic Model (TRAM) to perform comparative analyses of alternative candidate systems resulting in the selection of the optimal training system alternative, based on externally imposed constraints and cost/schedule factors.

The initial source of information was a task analysis data base provided to Calspan by the B-1 SPO. The task analysis data were subsequently translated into computer acceptable format and stored as a computerized data base. In the B-1 SAT process, task analysis information, alone with all necessary supporting data was compiled, managed, and manipulated with a computer Sorting Program. In the next phase, behavioral objectives were written which delineated the "who, what, how, when, and how well" of each definable behavior required to perform the mission. Included in the objectives are such things as criticality and difficulty information, specific crew coordination requirements, and a detailed listing of the supporting behaviors (enabling and ancillary objectives).

The behavioral objectives not in the trainee's incoming repertoire and the performance standards which the trainee is to demonstrate, comprise the training requirements. Existing knowledge of psychological learning principles and educational methods and training devices were combined in the methods media selection process. The applicable training devices and instructional strategies were used as inputs to the process of developing and ordering the instructional blocks into course syllabi.

A Training Resources Analytic Model was used to conduct trade-off analyses considering the many constraints of external influences, such as number of air vehicles to be manned, expected crew member attrition, airborne training time limitations, available fuel, and so forth. The application of TRAM to the course design by comparative evaluation of alternative schemes allowed the preferred instructional system to be selected on the basis of documentable criteria; notably, time and cost factors.

1.2 ADVANTAGES IN THE USE OF SAT METHODOLOGY

The primary advantage of the SAT methodology is that the various components of a training program are developed in the context of the entire training system. That is, the instructional strategy and training facility requirements are developed in conjunction with the course syllabi. This integrity within the training system ensures that the resources (both devices and facilities) will be utilized efficiently.

A second, and at least as important, advantage of the SAT methodology is that it tends to assure that the training is comprehensive and pertinent. Pertinency is derived from the fact that a detailed analysis of the operational tasks and their performance requirements is conducted as the first step in the SAT process. This ensures that only the relevant information required to perform the operational task is incorporated into the instructional curriculum. Due to the combination of reducing the "unnecessary" information and efficiently utilizing the resources, the SAT methodology results in cost-effective training over the life cycle of the training system.

1.3 LIMITATIONS OF THE SAT METHODOLOGY

Although the development of the SAT methods is an important advance in training technology, SAT is not a panacea for all training development ailments. Rather than being an algorithm that "spits out" answers, SAT is simply a "decision aid" to be used in documenting and presenting the information to managers. That is, the SAT process establishes the potential trade-offs involved and the relative costs and pay-offs of these trade-offs. It is this information upon which managers must make decisions involving expenditure of funds. As in the case of essentially all decisions managers must make, there is obviously not one, and only one, solution to the question.

One of the primary problems faced in developing training systems is the lack of quantitative relationships among the factors that affect the system. Probably the most obvious area of insufficient quantitative information is the relative training effectiveness (transfer effectiveness ratios) of various training devices (e.g., procedures trainers and full mission trainers). Another example in which quantitative assessment cannot be made is the benefits of crew coordination. It is difficult to assess the impact of crew coordination on "mission performance" and translate that impact into dollar costs.

The lack of quantitative data affects the SAT process in that quantitative data are required as inputs for the systems analysis aspects of SAT. Although problems do exist in the SAT methodology, it provides the decision-maker with a concise documentation of the assumptions (both quantitative and qualitative) that must be considered when developing a training system.

1.4 ADVANTAGES AND DISADVANTAGES SPECIFIC TO THE B-1 SAT

The B-1 SAT program is the first time an instructional system was developed for a major Air Force weapons system while the weapon system is still in development. The lead time that is provided makes it possible to determine the training device requirements on the basis of training requirements (curriculum) rather than retrofitting the curriculum to utilize previously procured hardware. Therefore, specification of training devices is much less speculative. It also allows sufficient time for device development and scheduled delivery of training devices when they are needed to begin training.

Another advantage encountered in carrying out the B-1 SAT program was the similarity of the operational mission to the one currently existing for operational air vehicles (B-52 and FB-111). Due to the similarity of the mission of the B-1 and the B-52 and FB-111, Subject Matter Experts (SME) were available and were included on the team that developed the task analysis. In addition, as the outputs of the SAT process were developed, they were discussed with FB-111 and B-52 instructor personnel to assure their usefulness by the Strategic Air Command.

The lead time provided by developing the training system during the development phase of the air vehicle that was previously mentioned as an

advantage to the B-1 SAT also results in serious disadvantages. The obvious limitation is the lack of information about the operational air vehicle. Both the lack of data and changes in the data pertaining to the operation of the air vehicle system affect the determination of crewmembers' job performance requirements. This difficulty encountered within the B-1 SAT was minimized by frequent interactions with personnel from Boeing, Rockwell International, Strategic Air Command, and B-1 Systems Program Office who were familiar with the B-1. To accommodate the changing nature of the behaviors performed by the B-1 crew, Calspan translated the task analysis received from the B-1 SPO into a computer acceptable format. Through the use of computer manipulation and storage, the data can be accessed and altered both during the contract period and by the using command (SAC) after the Calspan contract is completed.

An area in which data were not available, which is associated with the previous problem, is that the task analysis data provided to Calspan represented a "success-oriented mission." That is, malfunctions and the behaviors associated with them were not included in the task analysis. Calspan's solution to this problem was to derive the task analysis for malfunctions from the first flight manual in conjunction with the "Mockup Demonstration of Contingency Flight Crew Procedures" (NA-74-531) and the "Human Engineering Data on Attention Getting Devices in the B-1 Flight Station" (NA73-340-17). This approach is appropriate due to the fact that the initiation cues for the behaviors are primarily provided by annunciator panels and the Central Integrated Test System (CITS) and the correct responses are of a procedurized (checklist) nature. A related deficiency in the data base was the lack of those tasks that are non-EWO mission oriented (e.g., CONUS air regulations). To deal with this, comparisons of the B-1 system were made with other SAC weapons system training procedures.

With respect to the systems analyses conducted within the B-1 SAT process, the major problem was in making realistic assumptions to the state of affairs several years in advance of when the first air vehicle is delivered. To accommodate changes in parameter values as assumptions become known information, Calspan developed the Training Resources Analytic Model in which parameter values can be altered and the resulting impact on the training program costs and time phasing can be evaluated.

Although the SAT methodology is not a total solution for training system development problems, the techniques have been, and are being, refined to where it is a very useful "tool" for training program decision-making. Particularly considering the problems inherent in performing a SAT on a "yet-to-be" system, the documentation process of SAT is a requirement. That is, although the data base is fluid, the assumptions and assertions upon which decisions are made are well documented and communicable.

Section 2

METHODOLOGY USED IN B-1 SAT

The SAT process is comprised of a number of relatively distinct steps. The number and titles of the steps varies within the literature. The following list illustrates the steps and the sequential order of performing those steps.

1. Analyze the operational mission.
2. Identify behavioral objectives.
3. Establish the training device requirements.
4. Develop the course syllabi and student management structure.
5. Develop courseware and hardware.
6. Train the instructor personnel.
7. Implement the training program.
8. Evaluate, validate, and revise the program on a continuing basis.

The Calspan B-1 SAT program has progressed through the first four of these steps. The detailed flow diagram of the B-1 SAT is illustrated in Figure 1.

2.1 ANALYSIS OF THE OPERATIONAL MISSION (TASK ANALYSIS)

2.1.1 Purpose of the Task Analysis

The goal of a Systems Approach to Training methodology is the design and development of a training program that is valid with respect to the job requirements imposed by the mission to be accomplished. That is, all of the necessary skills and knowledges must be taught while ensuring that information that is simply "nice to know", although not necessary, is not included. The philosophy behind the systems approach is that if the crew does not operate upon the information, it is not necessary for them to learn that information. The foundation of any valid training program, therefore, must be an objective data base that encompasses the crew members' job performance requirements in an operational (and training mission) environment. Developing a crew training program on such a data base ensures that the training is relevant to the mission, rather than training simply for training's sake. Through the use of a mission-oriented data base, the most cost-effective training program can be developed by reducing unnecessary time and resource requirements. Resources, particularly in the form of costs, are reduced by the specification of training devices that are completely adequate for the purposes of transfer-of-training, while ensuring that overly-complex (costly) devices are not specified. To develop the necessary data base, the techniques of task analysis (referred to as skills analysis when dealing with task microstructure) has proven to be a useful tool.

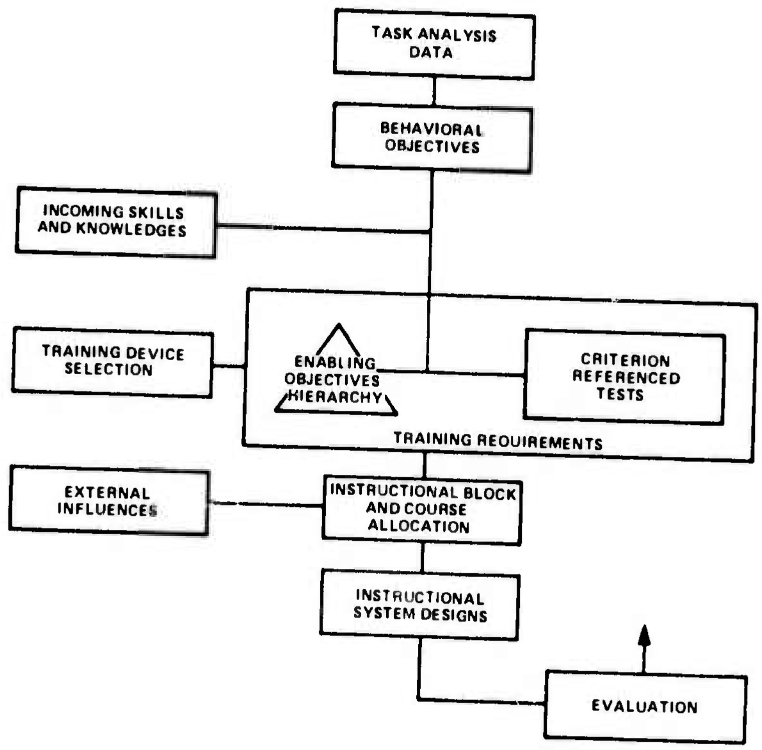


Figure 1. INFORMATION FLOW DIAGRAM

A task analysis team was assembled by the B-1 SPO for the purposes of developing the format of the analysis and actually developing the task analysis data base. The team was comprised of representatives of the Air Force Human Resources Laboratory, Strategic Air Command, Rockwell International Inc., and the Boeing Company, in addition to B-1 SPO personnel. This team spent an extensive amount of time both individually and in conference on the B-1 SAT effort.

2.1.2 Level of Detail of the Task Analysis

The levels of detail used in the B-1 SAT program consist of: (1) mission segments (e.g., refueling), (2) functions (e.g., rendezvous), (3) tasks (e.g., descent), and (4) task elements (e.g., reduce power). The task element is the smallest unit of behavior which is either perceptual-motor or cognitive in nature. This hierarchy of levels of detail proved to be effective for collecting task analysis data for the purposes of developing a training program. A distinction should be made between task analyses conducted for the purpose of developing a training system. In the former case, simple actions such as flipping toggle switches can require considerably more detail. For example, the time required to move from one switch to another has implications as to their relative location when one is designing panel layouts. However, this aspect of the task is of little importance (with rare exceptions) to the training program designer. The workspace has already been "human factored" prior to the training specialist's entrance on the scene, and the movement times are far less important to him than the sequence of events. An exception to this arises if the movement times influence task loading which, in turn, impacts on the training requirements. Therefore, the level of detail necessary for a task analysis for training program development is not as high as is necessary for equipment design. In fact, many SAT programs in the past have been hindered by the level of detail used (e.g., Air Force Project 1710, Clark, 1974).

In the same sense that the task analysis can be too detailed, many of the quantitative techniques of systems analysis are more rigorous than useful. For example, operational sequence diagrams (OSD) entail more information than is necessary for training system design. Two aspects of an OSD are important, however. First, a time line is necessary in order to determine task loading and sequencing information. However, in many (in fact most) cases, the exact times are not necessary, due to the fact that the sequence is what is of importance and that most missions are dynamic in nature. The second component of an OSD that is important in the design of training systems is crew interaction (including ground radio operators, refueling tanker personnel, etc.). This information, along with the other information included in the task analysis data base, is discussed in the next Section.

2.1.3 Task Element Attributes

The information in the task analysis data base includes the descriptive titles of the mission segment, function, and task. In addition, the

attributes of the smallest unit of behavior, the task element, are as follows:

- Task element title.
- Task element number.
- Operator.
- Behavior.
- Task duration
- Crew interaction.
- Previous task element.
- Next task element.
- Comments (categorized).

The task element title and number are simply accounting information which allow one to identify the element and equate identical task elements that occur throughout the mission. The operator is the crewmember performing the behavior. The behavior describes the actual activity occurring in the task element. This behavior consists of stimuli that cue the operator to initiate an action, an action phrase (e.g., push the throttles), and stimuli that cue the operator that the activity is completed. A more detailed format utilized for the behavior attribute is discussed in the next Section.

The task duration corresponds to the time required to accomplish the task elements. These times can be seconds, continuous, or indefinite (depending upon the configuration). Crew interaction involves communication or coordination between the operator and one or more other individuals (other crew members, refueling tanker crew, etc.). Previous task element information is used to illustrate the functional dependencies among task elements. For example, the task element that results in electrical power being available must occur prior to the VHF radio being used. Note that the previous task element does not necessarily immediately precede the present task element. This information corresponds to "functional" sequences rather than "temporal" sequences. The next task element is the element that follows (temporally) the present task element. This information is utilized in developing the time line. The comments are supplemental information that may be of future aid to the analyst. Each comment is categorized as to which one or more of the task element descriptors to which it applies. The comments may, therefore, be screened to find those that are relevant to specific components of the task element data.

In addition to the core information, other supplemental information was provided by subject matter experts through the SPO and elsewhere. Examples of the types of supplemental information are task element "difficulty" and "criticality." It should be noted that it is often more appropriate to assign these values to composites of elements. It is often the case that difficulty and criticality values are quite different when elements are considered in isolation, as opposed to when they are performed either concurrently or consecutively in rapid succession. These values are assigned to the task level of the mission analysis.

2.1.4 Format of the Task Element Behavior

As previously discussed, the format of the behavioral attribute of the task analysis data base corresponds to the stimulus-response characteristics of the activity. The major components that characterize the behavioral aspect of a task element are as follows:

Initiation Cue--Action Verb--Control--Completion Cue.

The initiation cue is the stimulus complex that informs the operator to begin the activity. The initiation cue consists of a Boolean combination of relational statements. The relational statements involve a stimulus "source" (e.g., control or display), a relation (e.g., equal to, greater than), and a value (e.g., "on", 3000, "red"). An example of an initiation cue is: Altimeter - greater than - 10,000 feet and Mach Indicator - equals - 1.7 mach. The necessity for a Boolean combination results from the fact that some initiation cues consist of various situations, any of which could be met ("or" statement), or all of which must be met ("and" statement). The controls and displays are elements of a catalog which are described in Technical Memorandum SAT-8. The catalog is used for verification of the data as the task analysis information is entered into storage. This verification allows keypunch errors to be detected, as well as checking that the value assigned is appropriate for that control or display.

The action verb is selected from a standarized vocabulary of terms (e.g., pull, rotate, and align) that was developed as an adaptation of the work of Oller (1968). The action verb has a correspondence to the control which is operated upon.

The next component of the task description is the control. This is the grammatical direct object of the action verb. These controls are a subset of the entries in the Control/Display Catalog. It should be noted that it is sometimes the case that a "display" can be operated upon (e.g., monitor the altimeter) and, therefore, becomes the "control."

The completion cue is of the same form as the initiation cue. In fact, it is often the case that the completion cue of one task element is the initiation cue of the next task element. As with the initiation cue, the completion cues are Boolean combinations of relational statements. However, in the former case, there is only one conglomerate cue; whereas, in the latter case there are often two or more conglomerate cues, each of which leads to a different next task element. For example, when a decision is made by a crew member, two alternative actions (next task elements) might be possible, depending upon the information upon which the decision was based. A more common situation is the case where one completion cue represents the normal operation, and the other completion cues represent corrective actions. The format of the behavior is presented in Figure 2. Figure 3 gives an example from the B-1 mission, illustrating the task element behavior for setting the wing sweep for cruise configuration.

		INITIATION CUE			ACTION VERB	CONTROL OR DISPLAY	COMPLETION CUE		
		CONTROL/ DISPLAY	RELATION	STATE			CONTROL/ DISPLAY	RELATION	STATE
CONJUNCTION									

Figure 2. FORMAT OF TASK ELEMENT BEHAVIOR

BEHAVIOR

OF SETTING WING SWEEP ANGLE FOR CRUISE CONFIGURATION

		INITIATION CUE			ACTION VERB	CONTROL OR DISPLAY	COMPLETION CUE		
		CONTROL/ DISPLAY	RELATION	STATE			CONTROL/ DISPLAY	RELATION	STATE
		ALTIMETER	=	30000			WING SWEEP INDICATOR	=	45
CONJUNCTION	AND	POWER LEVEL INDICATOR	=	90	ADJUST	WING SWEEP CONTROL			

Figure 3. EXAMPLE OF TASK ELEMENT BEHAVIOR

2.1.5 Encoding the Task Analysis Data

Because of the vast amount of data involved in the task analysis and its expected fluidity over time, it was mandatory that a computer storage and retrieval system be utilized. There have been recent advances in the use of computers to store and manipulate task analysis data (Reardon, 1968; Reed, 1967; Tulley, Meyer, Oller, Mitchell, Reardon, and Reed, 1968; and Whiteman, 1965). The sorting program described in Technical Memorandum SAT-4 was developed for the purpose of verifying, manipulating, and retrieving the task analysis data. The forms which are used to encode the task analysis data, in preparation of being keypunched on computer cards, are described in Technical Memorandum SAT-7.

2.1.6 Analyst/Data Base Interface Capabilities

The rigor that is necessary to impose on the data in order to make it computer-acceptable can be a hindrance to both the training program developer and the instructor personnel that modify the program as modifications are necessary (e.g., new systems or procedures are added). To circumvent this restriction, interface capabilities have been developed to allow easier interaction between the training analyst and the computer data base.

The problem first arises during the encoding of the task analysis data. For example, for the B-1 air vehicle, the term Altimeter/Vertical Velocity Indicator is used as the name of one of the displays. Other, more common terms that define the same display (or its parts) are "altimeter," "vertical velocity indicator," "rate of climb indicator," etc. To allow the training analyst more latitude during data encoding, a Display and Control Catalog is used to equate these terms. This capability of using synonyms (including jargon) has proved useful to the training developers and it is anticipated to be useful to the individual instructor personnel during future program modifications. In addition to the control and display names and synonyms, the following descriptive information is included in the catalog:

- Subsystem (e.g., flight controls, weapons, ECM)
- Location (e.g., lower-left pilot's panel)
- Type (e.g., lever-locked switch)
- Values (values or ranges that the display or control can assume)
- Categorized Comments (analogous to the task analysis encoding format in which comments are coded as to the descriptor(s) to which it pertains)

This information is useful in developing behavioral objectives based on systems (controls and displays). The sorting program can retrieve such information as "which controls and displays are on the copilot's panels." This information is also valuable in defining training device requirements.

A second interface capability involves the use of synonyms for action verbs. An Action Verb Thesaurus has been developed to relieve the analyst of the necessity to memorize (or look up) the action verbs. For example, the terms "reply" and "respond" are synonyms for the purposes of the task analysis. The analyst can use either term during the encoding of the data or utilizing the sorting program, and the computer will translate it into the formal name (in this case, "reply").

A report format of the Control and Display Catalog and the Action Verb Thesaurus is available to assist the analyst (Technical Memorandum SAT-8). A listing of the task analysis data developed utilizing this report is included in Technical Memorandum SAT-7.

2.1.7 Identification of Behavioral Objectives

2.1.7.1 Transformation of Task Analysis Data into Behavioral Objectives

The first step in developing the behavioral objective is to partition the totality of task elements into behavioral components. These components can be characterized as being: (1) maneuvers, (2) checklists, or (3) procedures (memorized checklists). For example, in the case of the B-1 SAT, the total mission is composed of 34 maneuvers.

The first-cut behavioral objectives are developed for each of these behavioral components. The sorting program is used to determine the commonalities that exist among the task elements (e.g., which task elements make use of a particular control; or, when is the aircraft in a particular configuration). To determine behavioral commonalities among the task elements, it is necessary to first determine the skills and knowledges necessary to perform the actions. Skills, as defined for this purpose, refer only to perceptual-motor behaviors which require coordination and timing. Therefore, a covert response such as "calculation" is considered as being a knowledge because there is no motor aspect to the operation. Because skills are composed of overt motor responses (actions), the action verbs (in combination with the performance limits) define the skills necessary to perform the task element. A distinction to be drawn is between "simple actions" and a skill. A simple action does not require coordination (e.g., flipping a toggle switch), whereas a skill does (e.g., tracking). Although all of the action verbs represent a response, it is obvious that most of the responses are "simple actions" and, therefore, are in the trainee's repertoire prior to his entering the training program. Tracking responses, such as those that occur during instrument landings and aerial refueling, represent one of the most complex categories of skills.

In developing the behavioral objectives, additional effort is required in the transformation of the task elements into knowledge categories. The categories include:

1. Identify (vocabulary)
2. Recognize
3. Recall
4. Locate
5. Interpret
6. Calculate (algebraic)

When the skills and knowledges are analyzed for each task element, it is possible to compare task elements to establish commonalities. These commonalities are the basis for synthesizing across elements to form aggregate behavioral objectives. That is, if the pilot is required to determine his altitude during both cruise and landing, it might represent one, rather than two, behavioral objectives. The data are now in the form of stimulus-response terminology that illustrate the skills and knowledges necessary and the proficiency needed to accomplish the mission which is the Behavioral Objective format.

2.1.7.2 Behavioral Objective Format

The format of the behavioral objectives is illustrated in Figure 4. The specific attributes of the behavioral objectives are as follows:

- Behavioral objective title.
- Initial conditions
- Concurrent behaviors.
- Behaviors.
- Performance criteria.
- Enabling objectives.
- Ancillary objectives.
- Operators.
- Interactions.
- Task elements accounted for.
- Objective criticality.
- Objective difficulity.

The behavioral objective title is simply a descriptive identification. The initial conditions illustrate the state of the aircraft prior to conducting the objective behaviors. An example of initial condition information is that the vertical velocity of an aircraft is at a particular value prior to conducting a level-off. The initial condition information is derived from the previous task elements of each of the behaviors. That is, the terminal state of the previous task element(s) corresponds functionally to the necessary initial conditions of each of the behaviors performed within the objective. An aspect of the objective that also has an impact is the description of concurrent tasks. For example, during a maneuver of initiating a climb, it might be required that the operator maintain a constant heading. This information is necessary in order to determine the difficulty and criticality of the objective.

OBJECTIVE: TITLE OF OBJECTIVE

INITIAL CONDITIONS: STATE OF THE AIR VEHICLE (e.g., CLIMBING AT 2000 ft/min, ELECTRICAL POWER AVAILABLE, ETC.)

CONCURRENT BEHAVIORS: OVERT OR COVERT BEHAVIORS CONDUCTED SIMULTANEOUSLY WITH THE OBJECTIVE BEHAVIORS. (e.g., MAINTAIN CONSTANT HEADING THROUGH MANEUVER)

BEHAVIORS:

INITIATION CUE					COMPLETION CUE		
CONTROL/DISPLAY	RELATION	VALUE	ACTION VERB	CONTROL OR DISPLAY	CONTROL/DISPLAY	RELATION	VALUE

PERFORMANCE: CRITERIA FOR DEMONSTRATING PROFICIENCY

ENABLING OBJECTIVES: SKILLS AND KNOWLEDGES NECESSARY TO ENABLE THE TRAINEE TO PERFORM THE BEHAVIORAL OBJECTIVE WITHIN THE SPECIFIED PERFORMANCE LIMITS.

ANCILLARY OBJECTIVES: SKILLS AND KNOWLEDGES NECESSARY TO HANDLE ABNORMAL EVENTS.

OPERATORS: WHO IS PERFORMING THE BEHAVIOR.

INTERACTIONS: CREW COORDINATION.

TASK ELEMENTS: TASK ELEMENTS INCORPORATED BY THE OBJECTIVE.

OBJECTIVE CRITICALITY: ON A THREE-POINT SCALE.

OBJECTIVE DIFFICULTY: ON A THREE-POINT SCALE.

Figure 4. BEHAVIORAL OBJECTIVE FORMAT

The behaviors involved in the objective are the same behaviors that are involved in the task elements that are encompassed by the objective. In fact, the format of the behaviors is such that they can be printed directly from the computer in report form. The basic components of the behavior are the initiation cue, action verb, control or display acted upon, and the completion cue. These components have been discussed in detail in Section 2.1.4.

The performance criteria that must be met to successfully perform the objective are one of the most difficult aspects in developing a "valid" training program. The limits must be referenced to the operational mission and reflect "necessary" criteria, below which the mission is hampered. The obvious key to the problem is the term "necessary." Although there is an abundance of data relating to basic research designed to determine the "capabilities" of human operators for various tasks, there is little (if any) data to support decisions regarding the minimum proficiency necessary to accomplish the assigned mission. With this in mind, the best solution to the problem of setting performance criteria is for training psychologists and Subject Matter Experts (SME), who are familiar with the mission requirements (task analysis data), to establish "appropriate" criteria based upon the mission requirements and the characteristics of the human operator. The performance criteria decided upon then constitute the criterion reference to be utilized in evaluating trainee proficiency levels. Within the rhetoric of SAT, this is referred to a criterion referenced testing (CRT). The feasibility and cost-effectiveness of automated performance measurement and automated, adaptive training is discussed in Section 3.3 and in Section 4.4 of Technical Memorandum SAT-3.

Enabling objectives describe the prerequisite skills and knowledges necessary to successfully perform the behavioral objective. These abilities include both overt and covert behaviors. Examples of covert behaviors include calculations, recall, etc. Coordination is an example of an overt enabling objective. Two task elements considered alone can give a totally different impression than the two considered as one action. For example, in level-off maneuvers, the throttle is reduced and the pitch control is manipulated. Each of these behaviors is relatively easily performed. The coordinated combination of the two that results in a smooth transition from climbing to level-off, without over-or-under shooting, is much more difficult. The purpose of the enabling objective is to make explicit the abilities necessary by synthesizing across the simple actions involved in the task data base. It is, therefore, an elaboration of the data base which is not handled adequately in stimulus-response terms. The knowledge necessary to accomplish the objective is a particularly important aspect of enabling objectives. This knowledge relates to principles and concepts that are necessary to perform what appears overtly to be a simple behavior.

Ancillary objectives are used to illustrate information that the operator needs to have in order to handle abnormal events. The B-1 task analysis data base represents a success-oriented mission and does not address malfunctions. Therefore, in addition to the enabling objectives necessary to

accomplish the successful mission, the ancillary objectives are necessary to handle malfunctions.

The operator is the crewmember that performs the behavior. Crew interaction involves the other crewmembers that the operator must coordinate with or receive information from. In addition to the crewmembers on the operator's own aircraft, crew interaction includes the interactions with the groundcrew (crew chief, carrier radio operators, etc.) and crewmembers of other aircraft (refueling tanker, etc.).

The task elements are the elements that the objective encompasses. When all objectives have been written, all task elements within the mission must be accounted for. The criticality and difficulty are subjective evaluations that are scaled from one to three. It should be noted that the difficulty and the criticality of the composite of the task elements can be greater than any of the task elements taken individually. The type and number of concurrent tasks also have an impact on the difficulty and criticality of the objective. An example of a behavioral objective (without specific values) is given in Figure 5.

As in the case of the individual task elements, the behavioral objectives may be thought of as being involved with one or more behavioral categories, although for behavioral objectives they are fewer in number and more globally defined. The categories that are relevant to this program are Perceptual processes, Mediational processes, Communication processes, and Motor processes (also referred to as perceptual-motor processes). The category of perceptual processes involves primarily detection, recognition, and identification. In this case, there is little or no interpretation involved, given that the stimulus (cue) is not masked. Drawing the analogy between this case and the "simple action" previously discussed, there is little more involved than mere orientation necessary to be able to accomplish this type of behavior. The second category into which an objective can be classified is that of mediational processes. This category involves what is commonly termed as problem solving or decision making. In this case, more complex algorithms are involved. The trainee must be taught the complex of probabilities, and costs-and-payoffs involved in the decision. This case, therefore, involves the presentation of information and the subsequent information processing. The third category is communication processes. This category involves the reception, interpretation, and transmittance of verbal information. This category is obviously a combination of the first two with the restriction that verbal material is being transmitted. Although this is true, this category has proved useful in delineating the instructional requirements for the objectives developed in the B-1 SAT. It is also recognized that mediation must involve perception of the information to be processed but the distinction is useful. The last category, motor processes, spans a continuum from simple/discrete movements (simple actions) to complex/continuous movements (e.g., tracking).

These characterizations have obvious implications with respect to training devices that are required to teach the objective. For example, many

OBJECTIVE: MAKE A COORDINATED TRANSITION FROM CLIMBING TO CRUISE CONFIGURATION.

INITIAL CONDITIONS:

VERTICAL VELOCITY: 2000	TEMP. AT DESIRED ALTITUDE: -55
POWER LEVEL: 100	DESIRED POWER LEVEL: 90
AIR SPEED: .5	DESIRED AIR SPEED: .8
ALTITUDE: 25000	DESIRED ALTITUDE: 30000
WING SWEEP: 16	DESIRED WING SWEEP: 45
A-V TRIMMED FOR CLIMB	

CONCURRENT BEHAVIOR: HEADING REMAINS CONSTANT

BEHAVIOR:

INITIATION CUE	ACTION	CONTROL OR DISPLAY	COMPLETION CUE
ALTIMETER = 29800	ADJUST	THROTTLES	POWER LEVEL IND. = 90
ALTIMETER = 29600	TRACK	PITCH IND. CONTROL STICK	PITCH IND. = 0 ALTIMETER = 30000
ALTIMETER = 30000 POWER LEVEL IND. = 90	ADJUST	WING SWEEP CONTROL	WING SWEEP IND. = 45
ALTIMETER = 30000 AIR SPEED = .8 WING SWEEP IND. = 45	ADJUST	TRIM	PROPRIOCEPTION = NEUTRAL PRESSURE

PERFORMANCE: AIR SPEED = .8 (± kts) AT CRUISE ALTITUDE.
ALTITUDE = 30000 (± ft) FROM DESIRED ALTITUDE AT CRUISE (TIME < sec).
SUBJECTIVELY SMOOTH VERTICAL FLIGHT PATH (e.g. REASONABLE g FORCES).
WING SWEEP = 45 (± deg) AFTER ADJUSTMENT (TIME < sec).
HEADING ERROR = 0 degrees FROM DESIRED HEADING (± deg).

ENABLING OBJECTIVES:

CALCULATE — NECESSARY POWER LEVEL FOR CRUISE AIR SPEED.
: ALTITUDE, TEMPERATURE, DESIRED TRUE AIR SPEED.

CALCULATE — NECESSARY ALTITUDE TO INITIATE POWER LEVEL CHANGE.
: INITIAL VERT. VELOCITY, DESIRED ALTITUDE, AIRSPEED, DESIRED AIRSPEED, A-V CHARACTERISTICS.

CALCULATE — NECESSARY ALTITUDE TO INITIATE PITCH CHANGE.
: VERT. VELOCITY, DESIRED ALTITUDE, AIRSPEED, A-V CHARACTERISTICS.

COORDINATE — THROTTLES AND CONTROL STICK TO ACHIEVE A RAPID TRANSITION HAVING THE g FORCES WITHIN CRITERION WITHOUT UNDERSHOOT OR OVERSHOOT.

PREDICT — NECESSARY PITCH CHANGES FOR LEVEL-OFF AT DESIRED ALTITUDE FROM THE VERTICAL ACCELERATION AND THE RATE OF CHANGE IN PITCH.

TRACK — PITCH INDICATION WITH CONTROL STICK TO REMAIN AT ZERO PITCH AT LEVEL-OFF.

TRACK — HEADING INDICATION WITH RUDDERS AND CONTROL STICK TO REMAIN AT DESIRED HEADING THROUGHOUT MANEUVER.

TASK ELEMENTS:

6.1.1.1	OPERATORS:	PILOT (AND COPILOT)
6.1.1.2	INTERACTIONS:	DSO PROVIDES HEADING DATA
6.1.1.3	TIME:	INDEFINITE, DEPENDING UPON CONDITIONS
6.1.1.4	CRITICALITY:	2
	DIFFICULTY:	2

Figure 5. BEHAVIORAL OBJECTIVE ILLUSTRATING A MANEUVER

of the mediational processes can be instructed using very simple devices (static, non-interactive), whereas, a complex/continuous motor process requires a complex device (dynamic, interactive). The dimensions along which training devices vary and their implications for device selection are discussed in Section 3.5 of the Simulation Technology Assessment Report (Technical Memorandum SAT-3).

2.1.7.3 Enabling Objective Hierarchy

The enabling objectives, as defined in the previous section, are prerequisite skills and knowledges that are necessary in order to successfully accomplish the behavioral objective. The question then arises whether the entering trainees possess these abilities prior to their entrance into the training program. If the objectives can be performed within the performance criteria, instruction (for that trainee) is not required as a component of the training system.

A personnel qualifications catalog is a useful tool in the process of documentation and subsequent evaluation of the trainee's ability to accomplish the enabling objectives. The personnel qualifications catalog format that was developed for this study is illustrated in Figure 6. The column headings represent the sources of trainees coming into the training program. The rows within the matrix corresponds to the control and display systems utilized in the aircraft into which the trainee is transferring. The matrix is filled in by the use of rating scales that illustrate the incoming trainee's previous "acquaintance" with the systems. The ratings and their definitions are shown in Table 1. An example page is illustrated in Figure 7.

If an enabling objective is already in the trainee's repertoire of abilities, the enabling objective is eliminated as being of concern with respect to the training of that trainee (or group of trainees). If the enabling objective is determined to be not in the trainee's repertoire, it remains in the training program and becomes a training objective in its own right. Therefore, the definition of a training objective, as used here, is the set of behavioral and enabling objectives that are not already in the incoming trainee's repertoire of abilities and, therefore, must be trained.

It should be noted that an enabling objective that has been determined to be a training objective can have enabling objectives required for it. This "second echelon" of enabling objectives is then evaluated in the same manner as the first. If it is not in the trainee's repertoire, it becomes a training objective and a "third echelon" is developed, and so on. It is also possible that an enabling objective can be "enabling for more than one higher level objective." Figure 8 illustrates a possible system of objectives with the enabling objectives being re-named training objectives, if they are not incoming abilities.

This system of objectives develops into an objective hierarchy with each successive level a prerequisite of the next level. Figure 9 illustrates

	B-52				FB-111		UPT	UNT	EWOT
	P	C	N/B	EWO	P	NAV.			
B-1 CONTROLS/DISPLAYS									

Figure 6. INCOMING ABILITY MATRIX

Table 1.
CLASSIFICATION OF INCOMING ABILITIES

- A – PRESENTLY USING IDENTICAL EQUIPMENT.
- B – PRESENTLY USING EQUIPMENT WITH IDENTICAL FUNCTION BUT DIFFERENT OPERATION.
- C – PRESENTLY USING EQUIPMENT FOR SAME PURPOSE BUT FUNCTIONALLY DIFFERENT
- D – NEVER USED COMPARABLE EQUIPMENT.

ITEM	CONTROL DISPLAY CODE	USING CREW MEMBER	FB-111	
			P	N
FLIGHT CONTROL STICK	S1-1	P-CP	A	
SCAS PITCH SWITCH FLIGHT TEST ONLY	S1-2.1	(P)-CP	C	
SCAS ROLL SWITCH FLIGHT TEST ONLY	S1-2.2	(P)-CP	C	
SCAS YAW SWITCH FLIGHT TEST ONLY	S1-2.3	(P)-CP	C	
STICK SHAKER SWITCH	S1-2.4	(P)-CP	B	
STANDBY PITCH TRIM CONTROL	S1-3.1.1	P	C	
YAW TRIM CONTROL	S1-3.1.2	P	C	
STANDBY PITCH TRIM CONTROL	S1-3.2.1	CP	C	
YAW TRIM CONTROL	S1-3.2.2	CP	C	
TRIM FOR TAKEOFF SWITCH	S1-3.2.3.1	(P)-CP	C	
TRIM FOR TAKEOFF LIGHT	S1-3.2.3.2	P-VP	C	
PITCH & ROLL TRIM CONTROL	S1-3.3	P	A	
PITCH & ROLL TRIM CONTROL	S1-3.4	CP	A	
PITCH TRIM SWITCH	S1-4.1	P-CP	C	
ROLL TRIM SWITCH	S1-4.2	P-CP	C	
YAW TRIM SWITCH	S1-4.3	P-CP	C	
PITCH AUGMENTATION SWITCH	S1-4.4	P-CP	C	
ROLL AUGMENTATION SWITCH	S1-4.5	P-CP	C	
YAW AUGMENTATION SWITCH	S1-4.6	P-CP	C	
FLIGHT CONTROL STICK DISCONNECT	S1-5	P-CP	D	

Figure 7. EXAMPLE OF PERSONNEL QUALIFICATIONS MATRIX

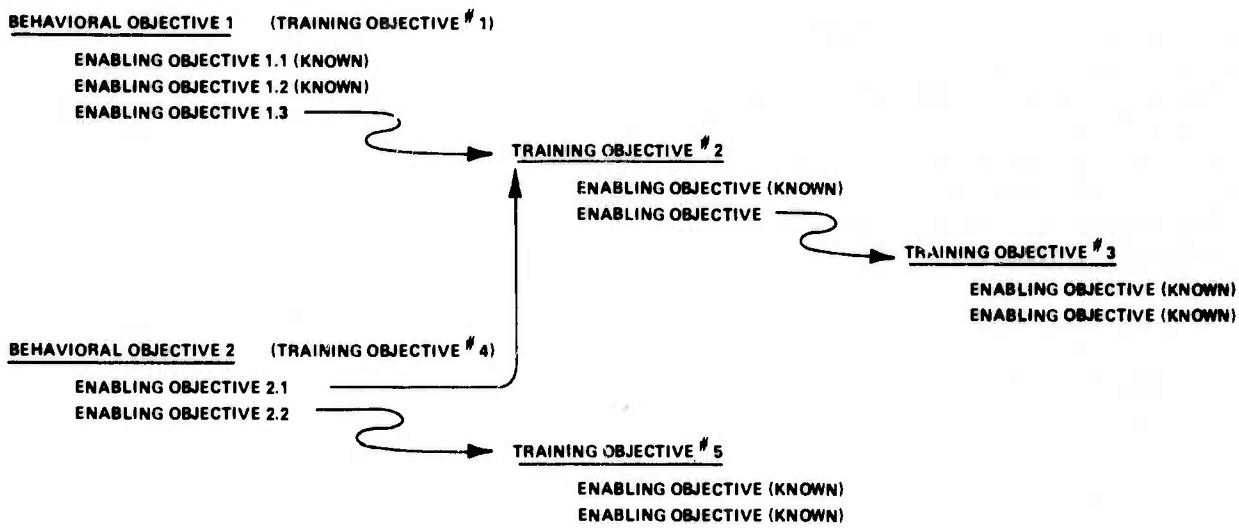
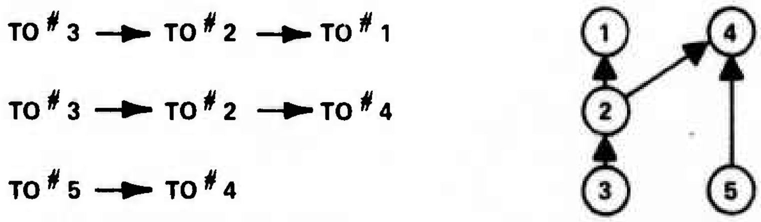


Figure 8. FORMULATION OF AN ENABLING OBJECTIVE HIERARCHY



(a) TRAINING OBJECTIVE SEQUENCE

(b) SCHEMATIC OF HIERARCHY

Figure 9. RESULTING OBJECTIVES HIERARCHY

the training objective sequences determined by the objective system (Figure 8) and a schematic representation of the resulting objectives hierarchy. The sequential dependencies of the objectives has implications, with respect to the instructional block sequence. The hierarchy, in its entirety, represents all of the information (skills and knowledges) that is included in the training program, with the successful accomplishment of the operational mission being the ultimate objective. The sequential dependencies were used in the iterative process of defining the B-1 aircrew instructional block sequences. It was found that the hierarchy was much "wider than it was high." That is, because of the highly automated nature of the B-1, a large number of instructional blocks (each a grouping of training objectives) are not directly dependent on preceding blocks. Furthermore, the formulation of a hierarchy of objectives within each block was beyond the scope of this study.

2.1.7.4 Establish Training Device Requirements

The development and implementation of an efficient training device (media) selection process is an important component in the design of any large-scale training program in which extensive use of media support is anticipated. The problems inherent in the specification of such a process, however, are many, as evidenced by the numerous attempts to develop a successful selection model. At the present state of educational technology, any method/media selection technique must be treated not as the answer to the media selection problem, but as a supplemental tool for the training systems designer. In using a model or methodology, training specialists must be aware of its attendant strengths and weaknesses and use the model accordingly.

A number of attempts have been made to simplify and improve the process of training device selection. Nine such attempts are reviewed in TAEG Report No. 8 (Braby, 1973). An in-depth examination was conducted of systems proposed by U.S. Air Force manuals 50-2 and 50-58, Bretz (1971), TAEG (1972), Briggs (1970), Rhode (1970), Walker (1967), and Boucher, Gottlieb, and Morganlander (1973). This examination, plus an examination of the implications of the TAEG Report No. 8, indicate that an optimal device selection system must contain the right blend of expert judgment, combined with a systematic categorization of training devices, according to the inherent attributes which define each device. Within an optimal selection system, training objectives should also be characterized in terms of the attribute requirements which training environments should possess to teach those objectives. By matching attributes of the training environment with training device attributes, appropriate devices for the training objective can be selected.

Such a matching approach, tempered with expert judgment, has recently been operationalized in the U.S. Navy's Training Effectiveness, Cost Effectiveness Prediction Technique (TECEP) (Braby, Henry, and Morris, 1974). The TECEP was derived by combining features from a number of the selection techniques cited above. In the TECEP approach to device selection, each training objective is categorized as one or more of 16 categories of learning. On the basis of the learning category identified, learning strategies are selected.

From the learning strategies, the attributes of the training environment for a training objective are derived. The attributes of the training environment are then matched with the attributes' training devices to select the candidate device alternatives for each training objective.

Guidance in formulating the B-1 training device selection technique used was taken from the TECEP technique; however, due to the mission-oriented nature of the B-1 SAT program, several changes in emphasis were instituted so that the selection technique would be maximally compatible with the goals of the B-1 SAT program. The training device selection process is illustrated in Figure 10.

For each training objective, the stimulus cue attributes of the operational environment in which the objective will be executed are identified. From this set of attributes, those stimuli which are necessary for proper training of the objective, at various stages of training, are identified and are used as the set of stimulus attributes against which potential training devices are evaluated. For a detailed discussion of the attributes, refer to the Simulation Technology Assessment Report, Technical Memorandum SAT-3.

Media-trainee interaction requirements for each training objective are derived from two sources: (1) learning guidelines which are based on the kind of learning inherent in each training objective (e.g., recall, continuous movement, crew coordination); and (2) basic principles of learning which are applicable across different kinds of learning (e.g., type of pacing, knowledge of results). The basic established principles of learning and guidelines for learning can be implemented in a system that includes three factors: individual versus group setting, self-paced versus instructor-paced, and linear, cycled, or branching logic. The precise specification of feedback to include content, timing, and form, and the specification of trainee response modes can better be determined within the context and environment in which each training objective will be taught and tested (criterion referenced tests). It has not been found to be useful in this program to consider media for testing independent of training media. This is a consequence of the emphasis on active participation of the trainee in the training concepts employed. In specifying these attributes, two principles of learning are implemented whenever practical: (1) the use of frequent and positive feedback and (2) the use of active learning, in which overt responses are required.

The next step in the process is to identify candidate devices which possess the necessary stimulus and interaction attributes. From the devices identified in the matching process, that device which is the best-suited for the training objective and which is the most cost-effective in terms of initial purchase and maintenance costs and in terms of maximum utilization capability across training objectives is selected. In evaluating the impact of economic considerations on method/media selection, the output of the TRAM assists SAT analysts in determining trade-off relationships among various media combinations.

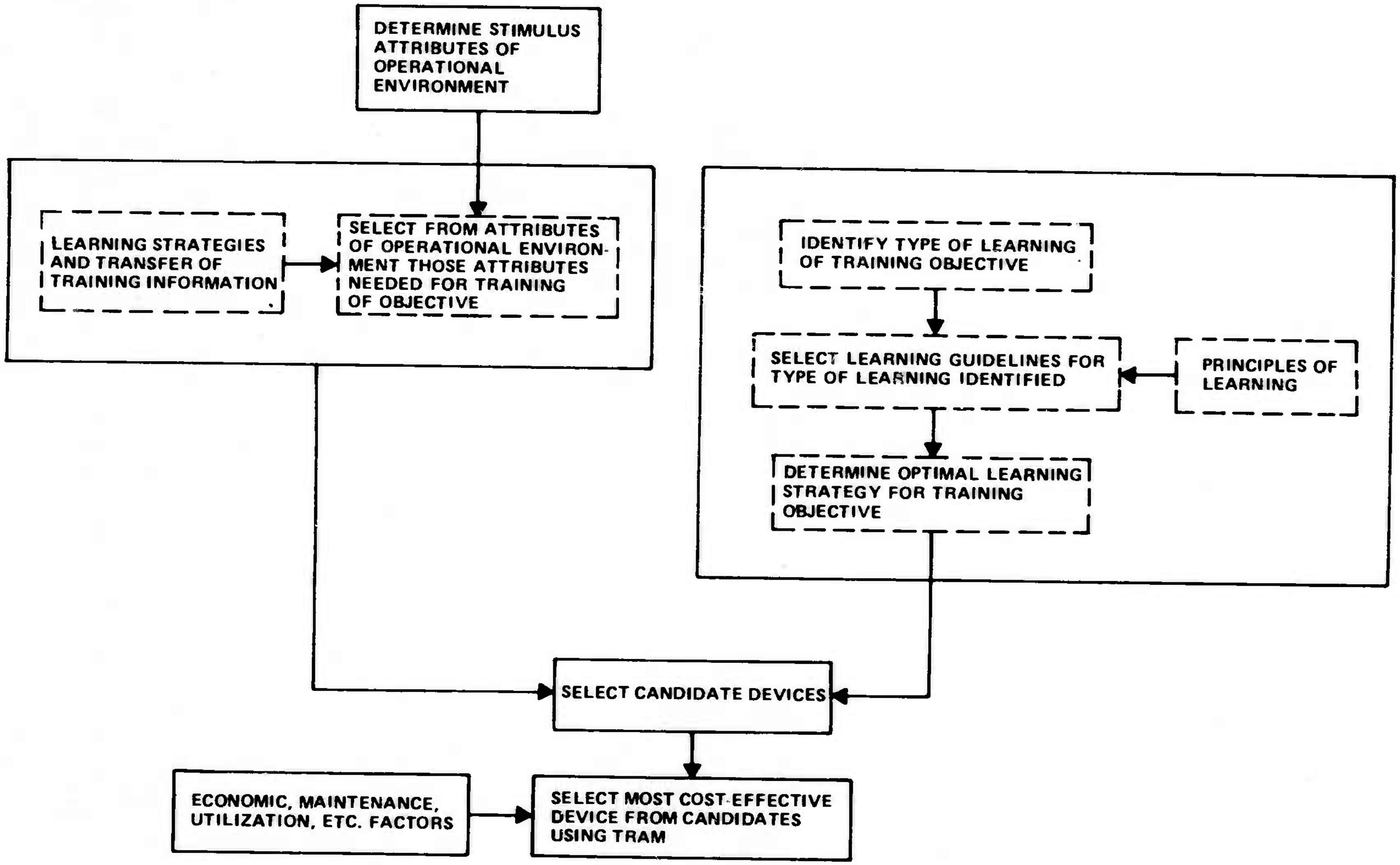


Figure 10. METHOD/MEDIA SELECTION PROCESS

The method/media selection process should not be carried out independent of instructional block allocation and sequencing, for the two processes are interactive. Commonalities among the devices selected for different training objectives may have impact on instructional block allocation, or logical groupings of training objectives into instructional blocks may impact on the device selection process. Consequently, the device selection process must be conceived as an interactive component of the overall development of instructional blocks in which SAT analysts may exercise different combinations of instructional blocks and devices in order to develop the training program that is optimal, both in terms of speed and quality of learning and in terms of cost-effectiveness.

2.1.7.5 Development of Instructional Specifications

Structuring and Scheduling of Courses, Tracks, and Instructional Blocks.

The primary purpose of developing the hierarchy of objectives is to use it as a tool in the scheduling of individual objectives on the basis of the sequential dependencies involved. However, this sequencing of objectives is only dictated by the hierarchy to the extent that there are dependencies. That is, in determining the relative scheduling of independent objectives, other considerations must be taken into account. For example, referring back to Figure 9, there are three sets of dependencies (3-2-1, 3-2-4, and 5-4). These dependencies illustrate that objectives two and five must precede objective four. It does not dictate, however, the sequential order of instruction with respect to objectives two and five.

There are three basic determinants that can be used in the scheduling of instruction, two are pedagogical and one is pragmatic. The first determinant is the sequencing on the basis of the dependencies within the objective hierarchy. This is the primary determinant, and cannot (with few exceptions) be violated.

The second determinant is the concept of context. In the case of training programs for combat aircrews, context is primarily derived from either "systems" or "phase-of-flight" information. With respect to aircrew training involving highly motivated and talented trainees, there is an instructional advantage to introducing the system (e.g., location and operation of controls) and the necessary concepts for initial interaction with the system while allowing the trainee to interact with the hardware as soon as possible. It is well known that active participation on the part of the trainee is important for efficient learning, but this active participation must occur within the correct context of phase-of-flight in order to establish a valid framework of associations.

The sorting program has been utilized extensively in the determination of instructional context. For example, a particular system (control or display) may be utilized in many different mission segments (phases-of-flight). The sorting program allows the analyst to rapidly search the data base (task analysis) to determine all of the task elements, and therefore, behavioral objectives, that involve that particular control or display. These objectives can then be analyzed to evaluate the commonalities. The decision is then made to group the objectives on the basis of system commonalities or not to group them, whichever results in stronger phase-of-flight context.

The third discriminant for determining the scheduling of instruction is resource management. This factor is pragmatic, rather than pedagogical. Although the objective hierarchy cannot be violated, resource management (training device and facility utilization) can take precedence over context considerations. The goal of the SAT process is the development of the most cost-effective training program. TRAM was used as a tool in evaluating the trade-offs involved between resource management and context.

Upon the basis of these three determinants, instructional blocks are organized into a course. Instructional blocks are groupings of training objectives based on the objective hierarchy, as well as context and resource management.

For any particular course, there can be a number of different sources of trainees. These sources have different incoming skills and knowledges. These abilities were documented as described in Section 2.1.7.3. The sources are subsequently compared for their homogeniety within and among sources and are compared with respect to whether they can be grouped into tracks. A track is a curriculum determined to be cost-effective, due to minimizing the inefficiencies resulting from covering material redundantly, or missing information not already in the trainee's repertoire. If the sources are heterogeneous, then there would be one track for each source.

The next sections describe the instructional system derived by following the procedures delineated in this section. The preferred instructional system which is the prime emphasis of the next chapters is, the most cost- and training-effective that the SAT methodology can provide.

Section 3

ANALYTICAL FINDINGS

3.1 INTRODUCTION

The primary products of this B-1 SAT study are the syllabi for the courses, functional descriptions of the proposed training devices and time-phased costs and resource requirements (training devices, aircraft, support personnel, trainees, and facilities). Detailed descriptions of these products are incorporated in the present report; however, an extensive amount of supporting information which played a central role in the SAT process up to this point is included in the documents listed on Page i.

Course syllabi of the preferred instructional system are described in this volume for the Pilot, Copilot, and Offensive Systems Operator. Included are Transition Training at the Combat Crew Training School (CCTS), Proficiency Maintenance Training (PMT), and Upgrade Training (copilot to pilot). The Defensive Systems Operator syllabus is presented as an estimate, since the task analysis for that station was not available in time to be included in the study. Also presented in this section are descriptions of the recommended training devices.

The next section will provide the results of the use of TRAM (the Training Resources Analytic Model). These include the time-phased resource requirements for the preferred instructional system and alternative systems based on alternative input parameters and any supporting sensitivity analyses. Time-phased costs and costing assumptions are included in Technical Memorandum SAT-1, Appendix A (unattached). The supporting information is briefly summarized in the following paragraphs.

3.2 SUPPORTING INFORMATION

3.2.1 Task Analysis Data Listing

As discussed in Section 2, the first step in the SAT process is to analyze the operational mission in order to derive the graduating trainee's job performance requirements. The data used as a basis for the task analysis were developed by a team comprised of individuals from the B-1 SPO, SAC, Rockwell International, and the Boeing Company. The data were provided to Calspan during the period July 1974 to January 1975, and were subsequently encoded into the computer-acceptable format described in Section 2.1.5. In addition to the "success-oriented mission" data provided by the SPO, Calspan developed the task analysis data for emergency procedures from the Flight Manual in conjunction with the "Mockup Demonstration of Contingency Flight Crew Procedures" (NA-74-531) and the "Human Engineering Data on Attention Getting Devices in the B-1 Flight Station"((NA73-340-17). These data were encoded into the same format as the normal procedures. The use of these documents to develop the task analysis was appropriate, due to the procedural (checklist) nature of

handling most malfunctions. A computer report of the task analysis data for normal and emergency tasks is included in Technical Memorandum SAT-7.

3.2.2 Analyst/Data Interface Capabilities

The task analysis resulted in a large amount of data that required storage and manipulation (approximately 1500 task elements). As discussed in Section 2.1.6, the inputing, manipulation, and outputing of these data required the implementation of interface capabilities between the user and the computer data base. These interface capabilities include the Control and Display Catalog described in Technical Memorandum SAT-8 and the Sorting Program that is described in Technical Memorandum SAT-4.

3.2.3 Behavioral Objectives

As discussed in Section 2.1.7, the task analysis data base was analyzed to determine the Behavioral Objectives that the trainee must be able to perform. The list of Behavioral Objectives for the B-1 crewmembers (excluding the defensive systems operator) is given in Technical Memorandum SAT-2. The extensive detail contained in the Behavioral Objectives is expected to be a major aid to those who will develop the courseware for the instructional blocks of the syllabi.

3.3 TRAINING DEVICE RECOMMENDATIONS

One important product of the B-1 SAT program is the determination of training device requirements based on training objectives as a function of the phase of training. The goal of the B-1 SAT was to develop an effective training program at the lowest possible cost. The selection of training devices has one of the greatest impacts on the training system's effectiveness and economy over the B-1 life cycle. To aid in this step, a Simulation Technology Assessment Report (Technical Memorandum SAT-3) was prepared which surveyed the engineering and behavioral aspects of training devices. That report details much of the information that the training analysts applied in arriving at the conclusions presented here.

There were two general "principles" utilized that result in effective and economic training device utilization. The first principle involves active participation of the trainee, generally termed early "hands-on" learning. This is accomplished through the use of a spectrum of devices in which the complexity of each device is consistent with the requirements of the students' level of training. That is, for example, the complexity required to instruct a trainee on the location and operation of "knobs and dials" when he is first introduced to a system is much less than the complexity required when, in later training, he is interacting with the same system in a real-time perceptual-motor coordination task.

The second principle which was followed in determining the device requirements was that for each training requirement, the minimum cost device was evaluated for its applicability. The burden of justification rests on

increasing the complexity (cost) of the device required to train the objective. Through this sequential evaluation of device applicability, in terms of stimulus (cue) requirements and instructional strategy, the lower complexity devices are utilized to the greatest extent possible.

With these principles in mind, along with the engineering and behavioral state-of-the-art in training devices discussed in the Simulation Technology Assessment Report and the selection procedures described in Section 2.1.7.4, nine training devices are recommended for the B-1 Combat Crew Training School (CCTS). These devices span a continuum from a relatively low complexity carrel to a highly complex integrated-crew mission trainer. A functional description of these devices is given in the present section. Facilities and costs are described in the next section and Appendix A, Vol. 2.

The terminology used within the training community when referring to various training devices is often confusing and, in many cases, misleading. The best example of this confusion is the often-used term "procedures trainer." These devices, although under the same name, span a spectrum of complexity from photographic mock-ups to totally interactive cockpit replicas. Similarly, what is referred to as a "full mission simulator" within one training program is often referred to as a "part-task trainer" in another program. There is presently a trend in training device description to use alpha-numeric designations without attempting to attach "descriptive" names. This approach has been adopted within the B-1 SAT program to ensure that the device name is not misleading, although descriptive names are also offered in this report.

The nine recommended devices were arrived at on the basis of an iterative process that involved examining the training requirements of tentative groupings of behavioral objectives (i.e., instructional blocks), determining the applicable media, restructuring instructional blocks to achieve a more economical media selection consistent with the learning strategy, and so forth. Five basic types of devices were defined as indicated in Table 2 , and are designated as: Device 0; Device 1; Devices 2/P/CP, 2/OSO, 2/DSO; Devices 3/P/CP, 3/OSO, 3/DSO; and Device 4, which is a coordinated combination of Devices 3/P/CP, 3/OSO, and 3/DSO. Devices 0 through 3 significantly differ from each other in complexity with corresponding differences in development and O&M costs.

Devices 0 and 1 are totally independent devices. A group of Device 2s may be linked by voice communications only, for the purpose of coordinated procedures practice. Device 4 provides full interactiveness between an ensemble of Device 3s, including limitations on each other's systems that may be imposed by concurrent use or by equipment malfunction. As such, Device 4 is significantly more than the sum of Device 3s and, hence, is given its own designation.

The trainee's performance will be recorded for instructor feedback (on-line in Devices 2, 3 and 4), as well as subsequent evaluation and modification of the training curriculum. The performance measures and corresponding formats used for the recording systems must be compatible across all devices at the CCTS and the Main Operating Bases (MOB), as well as at the SAC ISD

Team's facility (e.g., at SAC HQ or the CCTS). This requirement is to assure that both the CCTS training and the continuing (maintaining proficiency and pilot upgrade) training utilize standardized performance criteria. This is necessary for adequate evaluation and subsequent modifications of the entire training system.

Table 2

DEVICE DESIGNATIONS

Device \ Trainee	P/CP	OSO	DSO	ALL
0				X
1	X			
2	X	X	X	
3	X	X	X	
4				X

3.3.1 <u>Device 0 - General Purpose Carrel (All Crew Members)</u>

The simplest, and least costly device, is what is generally referred to as a general purpose carrel. The purpose of Device Number 0 is to provide student-centered individualized instruction of material that does not require active manipulation or monitoring of controls and displays by the trainee. It incorporates an audio-visual presentation, a workspace for writing, and a reduced photograph of the cockpit layout. The audio-visual presentation involves a student-paced narrated slide presentation that is linearly programmed (i.e., without branching logic) but with student-initiated recycling. The linearly-programmed attribute is recommended due to the homogeneity of the incoming abilities of the trainees within each track (curriculum). This homogeneity of the trainee population reduces the efficiency (cost-effectiveness) of more complex instructional strategies involving branching and even computer-assisted instruction (CAI). The use of a visual presentation for the sole purpose of including real-time motion (e.g., TV or film) is not a requirement for this device. In the cases where the temporal pattern of sequence is important, the pattern can be represented by "discrete real-time" advances of the slide presentation.

The instructional features of this device include a response recording system (e.g., four alternatives), performance assessment (i.e., correctness of choice), and progress monitoring via computer-managed-instruction (CMI). The recording system can be a multi-channel or multi-plexed magnetic tape system with the data processing (performance assessment and CMI) being accomplished through the use of the computer capability of one of the more complex devices (e.g., 2, 3, or 4) or an associated minicomputer. A library and librarian are associated with these devices, but an instructor need not be present, although one should be available for consultation.

The instructional features provided within this device result in increased instructional effectiveness. A second important function of these features is for the continual evaluation and modification of the training curriculum through feedback of students' progress vis-a-vis expected progress. The capability for this evaluation and modification is incorporated in all of the training devices recommended for the B-1 training system, as previously noted in the paragraph preceding these descriptions.

3.3.2 Device 1 - Familiarization Trainer (Pilot/Copilot)

The second level of complexity within the spectrum of trainers is a device that is used to familiarize the pilot and copilot trainees with the location and operation of cockpit controls and displays. Device 1 is comprised of a combination of "hard" and "soft" mockup instrumentation. For example, the controls (excluding the primary flight controls) are actual hardware or special fabrication (whichever is less costly) that results in approximately the same "feel" as the operational equipment. The meter-type instruments are dynamic, but with simplified (low fidelity) movements. For example, when a switch control is used that results in a meter reading that increases to a final state, the dynamics within this device will entail a ballistic movement of the meter. If the rate of meter movement, in addition to the stationary final state, gives information to the operator, then that behavior is instructed in one of the more complex devices. The lights and lighted legends within this device are operable (on-off) through the corresponding switches that control them. This device is used when practicing procedures (normal and emergency) that do not require high fidelity dynamic interactions (e.g., checklists).

As in Device 0, Device 1 utilizes a narrated slide audio-visual system in which the instructional strategy involves linear programming, as opposed to branching logic. This device also includes a trainee response system that is used for subsequent trainee performance assessment and progress monitoring. Through the use of audio-visual presentations and the response system, the trainee can be presented with a multitude of "situations." For example, a particular malfunction situation can be illustrated on a slide frame with the trainee being required to interpret the situation and manipulate the controls in the appropriate manner. Library and instructor requirements are the same as for Device 0.

3.3.3 Device 2 - Procedures Trainers

3.3.3.1 Device 2/P/CP Procedures Trainers

Device 2/P/CP is used to practice procedures that require complex interactions between the trainee and the equipment, as well as complex interaction among the components of the equipment. It has a work station for both the pilot and copilot. This device is totally interactive in terms of normal and emergency procedure tasks for operations both on the ground and during flight. Device 2/P/CP includes the total complex of system malfunctions (approximately 200).

The instrumentation in this device involves actual operational equipment or special fabrication that results in the appearance, dynamics, and kinesthetic "feel" that replicate those of the operational air vehicle. Exceptions to this description are the terrain following radar (TFR), the forward-looking infrared (FLIR), and the threat situation display (TSD). The capability of Device 2/P/CP does not include flight equation calculations. Therefore, the TFR, FLIR, EVS, and TSD presentations are not interactive in real-time. Slide presentations can be displayed on these displays to represent particular configurations that impact upon procedures.

The instructional features of Device 2/P/CP include a slide presentation that includes the computer control of the slide sequencing (CAI). The instructional strategy involves preprogramming of malfunctions, automatic response assessment, and subsequent slide presentations (e.g., feedback and remedial information). The sequence of instruction in this device is both self-paced and automatically tailored to the individual trainee (i.e. using branching). As an example, for a particular emergency procedure, the preprogrammed malfunction will occur. On the other hand, if the response was not satisfactory, the trainee will be informed of the correct response and the same malfunction will be performed again.

As in the case of Device 1, the visual slide presentation in this device can be used to supplement the instrumentation provided in the device. For example, the Central Integrated Test System (CITS) provides information about malfunctions to the aircraft's back station with this information being relayed to the pilots by the Offensive and Defensive Systems Operators. Through the use of the slide presentation, Device 2/P/CP can be operated independently of the back station training devices (description to follow). In addition, an instructor can play the part of the systems operators through the Intercom System (ICS). The instructor and instructor's malfunction insertion panel are colocated with the trainees' station. The front station device 2/P/CP is similar to those currently within commercial aviation training programs.

3.3.3.2 Device 2/OSO Procedures Trainer

The OSO procedure trainer (2/OSO) is used to practice navigation and weapons delivery tasks that do not require real-time radar presentations or continuous movements in space (i.e., maneuvering of the air vehicle). This device is totally interactive in terms of normal and emergency procedure tasks for operations on the ground (e.g., pre-flight checks) and during flight.

A major function of this device is to practice interactive navigation and weapons data input and access through the use of the integrated keyboard, CRT displays, and navigation panel displays. Another use of this device is to practice using the Central Integrated Test System (CITS) for abnormal operation procedures.

As in Device 2/P/CP, Device 2/OSO utilizes operational equipment or special fabrication that results in the appearance, dynamics, and kinesthetic "feel" that replicate those of the air vehicle. The only systems that cannot be operated interactively in real-time are the FLIR and attack radar presentations. These presentations are "canned" with video tape or film (e.g., 16 mm) as the storage medium.

The instructional features of Device 2/OSO are the same as in the previously discussed Device 2/P/CP. This includes branched instructional strategy, performance assessment, and, as with all of the devices, computer managed instruction (CMI). The instructor's station is also comparable to Device 2/P/CP.

3.3.3.3 Device 2/DSO Procedures Trainer

No training analysis, per se, was performed for the DSO, but in order to exercise TRAM and carry out facilities estimates, a hypothetical set of devices for the DSO was created. It is certainly not clear whether a Device 2/DSO will be required (perhaps all the synthetic training for the DSO will most cost-effectively use only Devices 0, 3 and 4); but if it is, it will probably be similar but not as complex as the Device 2/OSO. The B-1 SAT analysts conceive it as using computer-controlled branching of a slide presentation as does the Device 2/P/CP. Correct keyboard use would result in appropriate graphics-type displays. Error-occurrence messages could, as one possibility, be evaluated by the trainee by comparison of his hard-copy input and a displayed correct input. In this manner, the DSO trainer 3/DSO involves interactive passive detection data and readout capabilities (including the integrated keyboard), as well as a simulated CITS panel. Both the Threat Situation Display (TSD) and the Frequency Spectrum Display (FSD) will be included.

3.3.3.4 Device 2 Coordination

The purpose of these devices is to satisfy the training objectives that require interactive (man-machine and machine-machine) capability but do not involve the maneuvering of the "air vehicle" or trainee-controlled

alterations of the radar land-mass presentation (e.g., scale changes) as in the case of the OSO. These devices are to be linked by communications so that crew coordination of procedures may be practiced at designated points in the curriculum. It is planned that a single instructor can time share his monitoring between two of these devices when at least one of them is operating in a totally programmed (CAI) mode.

3.3.4 Device 3 - Part-Mission Trainers

3.3.4.1 Device 3/P/CP Part-Mission Trainer

The training devices that have been previously described have been progressing from a strictly academic device (0) to a hands-on, familiarization device (1) to an interactive procedures practicing device (2). This progression of devices is consistent with the progression of instruction from purely cognitive, enabling objectives to context specific orientation and then to perceptual-motor skill acquisition through practice. The skill acquisition that occurs in Device 2/P/CP is procedural in nature. That is, the behaviors practiced are sequential patterns of discrete responses, as opposed to continuous (maneuvering) behaviors that require both timing and coordination. This latter type of behaviors for the pilots is instructed through practice in Device 3/P/CP.

The phases of flight that require an extensive amount of pilot's practice in perceptual-motor tasks are (a) take-off, (b) refueling, (c) manual terrain following, and (d) landing. Device 3/P/CP is configured for the training of the objectives relating to these flight phases. The training objective instructed within this device involve high fidelity cockpit display information and precise motor control that requires cueing from both bodily motion and an external scene representation (e.g., aerial refueling contact).

This device can be partitioned into eight major interacting "components."

(1) Cockpit instrumentation
(2) Flight equation model
(3) Flight control system
(4) Sensor systems (FLIR and TFR)
(5) External visual scene presentation
(6) Trainer cockpit motion system
(7) Instructional features (performance measurement)
(8) Instructor/Operator station

The cockpit instrumentation component consists of the front station controls and displays excluding the FLIR and TFR. The simulation of these controls and displays is similar, at least in complexity of simulation, to many military and commercial aircrew training devices. One concern, with respect to simulator instrumentation, is whether to use off-the-shelf aircraft equipment or special fabrication ("simulated") equipment. The primary advantage of using aircraft instruments is the logistics involved in repair or replacement. One problem with this approach, however, is that aircraft instrumentation, while designed for severe environments, is not capable of withstanding the duration of utilization that is required of training device

equipment (e.g., 16 to 24 hours per day, 7 days per week). This trade-off between aircraft or simulated instrumentation must be considered on an instrument-by-instrument basis with no generalized solution being possible.

The flight equations modeling for an aircraft such as the B-1 is an expensive component of the system (in both computer hardware and software). The modeling involves both the dynamic structural modes of the air vehicle, as well as such things as wind gusts and shears, ground effects, and wheel strut and tire friction characteristics.

With respect to the mathematical modeling of the structural modes, a great amount of guidance can be derived from the aircraft design tests conducted on Rockwell International's simulation system. However, for the training Device 3/P/CP, it is not necessary to include the outer limits of the flight characteristics envelope which may be necessary in R&D simulations for air vehicle design tests.

Another aspect of the flight equation modeling of particular importance is wing sweep characteristics. It is possible to experience cost savings by utilizing "high-fidelity" modeling of only selected, discrete values of wing sweep (e.g., five discrete values: 15°, 20°, 25°, 45°, 67°). Center-of-gravity variation is another area in which the full range of values is probably inappropriate and where selected demonstrative values can satisfy the training requirements.

The adequate modeling of wind gusts and shears is important for the practice of take-off, aerial refueling, and landing. The trainee must learn the precise control required in these tasks and, particularly, to be able to anticipate the effects of gusts, shears, and ground effects. In the other phases of flight, turbulence is merely a disruption that increases the trainee's task loading and does not require precise modeling.

In addition to the modeling of wind gusts and shear effects, Device 3/P/CP also includes "realistic" modeling of ground effects, landing strut characteristics, and tire friction (e.g., icy runway) during both take-off and landing roll, as well as during flight. These capabilities can add training effectiveness to the device by providing "weather" characteristics that are difficult and possibly dangerous to obtain with the aircraft.

The flight control system (SCAS) simulation has similar considerations as the flight equations modeling. In the case of SCAS, it is important to include modeling of the "possible" malfunctions that can occur. That is, it is not necessary to simulate all of the possible malfunctions (and combinations of malfunction), but rather, only those that have high criticality and probability of occurrence.

The sensor systems that are provided to the pilots are the forward-looking infrared (FLIR) and the terrain following radar (TFR). The simulation of FLIR in a real-time, interactive mode is a problem that strains the present

simulation state-of-the-art. It is difficult to assess the impact of FLIR simulation on terrain following flight tasks. The FLIR is a secondary, and, therefore, non-essential system for operational terrain following. In addition, the capability of pilots to extract meaningful information from the FLIR during high-speed/low altitude flight is questionable due to the velocity of the flow pattern involved. Most FLIR training can occur in a non-interactive mode (e.g., FLIR interpretation and target detection); hence, real-time, interactive simulation of FLIR is assessed to be unnecessary for inclusion in this device. Interactive FLIR training can occur in the air vehicle without increasing flight time since the training is short in duration and not high in criticality. The Navy has taken this approach on the S-3A anti submarine warfare aircraft. If, contrary to these recommendations, FLIR is simulated, correlation with a visual scene presentation is required to ensure that inconsistencies do not occur in the cues provided by the two presentations.

The terrain following radar is basically the same system as is now being used in the FB-111 aircraft and simulator. The same data base can be used for the TFR as for the attack radar (described in the next section). For the purposes of training objectives involving manual and automatic terrain following when the pilots are independent of the OSO, a generic ("simulated") terrain data base is sufficient, as opposed to "real-world" terrain. The characteristics of this "simulated" terrain are manipulable and result in effective training (e.g., progression from easy to difficult) that is difficult to obtain with "real" data.

As discussed in the Simulation Technology Assessment Report, the requirements for a visual scene presentation are not very well understood. However, there are two factors that play a major part in determing the requirements. The first factor is the nature of the task with respect to its difficulty and criticality. In the case of the B-1, the phases-of-flight which require visual scene presentation are take-off, refueling, and landing. Another phase-of-flight in which external visual cues can assist (but are not required) is during terrain following. Visual scene presentation for terrain following operations is discussed later in the context of visual scene simulation capabilities.

The second factor is the experience level of the trainee population. That is, the visual simulation required to instruct undergraduate pilots is quite different from that required to transition an experienced pilot from one air vehicle system to a similar system. In the latter case, only a limited presentation is required to illustrate the differences between the systems (e.g., touchdown speeds and responses to control inputs).

For the purposes of satisfying training objectives for visual landing and take-off, a limited-cue presentation is sufficient. Making use of the training objectives and the Simulation Technology Assessment Report (STAR), the appropriate characteristics of the visual scene simulation are as follows:

Format	- point lights system (night-dusk system with runway and horizon shading)
Color	- limited (represents air field lighting, and refueling boom and director lights)
Brightness	- 6 fL (dusk lighting)
Interaction	- closed-loop
Movement	- continuous
Resolution	- 9 arcmin
Range	- 10 nm.
Extent	- (1) take-off - length of runway (2) landing - 10 nm (V-shaped) (3) aerial refueling - 50 ft. (observation position)
Field of View	- (1) vertical - 30 deg. (2) horizontal - 45 deg. (for each of two displays)
Atmosphere	- (1) ceiling - flat (as opposed to structured) (2) RVR - haze, fog, etc. (see range) (3) clouds - only ceiling (4) precipitation - none
Viewing Position	- correct perspective at both pilot and copilot locations

Visual simulations with comparable characteristics are presently being used for take-off and landing instruction in both military and commercial training programs. The system described need not allow for circling approaches, due to the limited operational use of this pattern for the B-1 air vehicle and the expectation that the fundamentals of such maneuvers are within the incoming skills and knowledge of the trainees.

The refueling phase poses a problem for the present state-of-the-art in visual scene presentation. It is not presently known which cues are necessary for refueling, other than the director lights. It is the case that different pilots use different cues. Therefore, an approach that is consistent with the SAT philosophy and results in extensive cost savings is to choose the cues and train the pilot to refuel using those cues. This approach is apparently effective in training pilots to fly in formation, which is a station-keeping task not unlike refueling. When the pilot practices refueling after training, the additional cues that he adopts assist him; however, most of the available cues are not necessary for "successful" accomplishment of the mission" which is the only truly valid criterion of device effectiveness. For example, night refueling using only the director lights is a good

baseline case of the "necessary" cues for refueling and would greatly simplify the functional requirements of the simulation. Given this approach, in combination with the expressed optimism of the simulation manufacturing industry (that the present advances in the "point-lights" system will ensure the refueling capability), this system involves a relatively low risk of satisfying the training requirements and is therefore recommended.

For the purposes of satisfying training objectives during terrain following, the operational mission of the B-1 dictates that the associated maneuvering be conducted in either of two ways. One is with no external visual references (i.e., under completely IFR conditions) and the other is with a very limited visual perspective because of the severely restricted field-of-view provided by the thermal flashblindness protection windows. Flying terrain following in IFR conditions is a considerably more demanding task than flying with reference to outside obstructions. Therefore, because of the "simpler" task when flying terrain following in VFR conditions and the limited visual perspective seen by the pilot, it is recommended that no visual simulation be provided in the terrain following phase of training. The instructional strategy is that once the trainee achieves criterion performance under the greater demands, he will adequately perform under any lesser demands.

The primary advantages to the computer-generated "point-lights" system are the low initial cost, relative ease of retrofit, fewer facility requirements (relative to terrain model systems), and ease of maintainability. As with all of the components of Device 3/P/CP, the correlation of the visual cues as presented and the information that the pilots receive from other sources (e.g., instruments and bodily motion) must ensure that conflicting cues do not arise.

The next component of Device 3/P/CP is the <u>cockpit motion system</u>. The term motion is used here to refer to bodily motion as opposed to movement which, as defined earlier, corresponds to visual inputs. As discussed in the Simulation Technology Assessment Report, there is much more emotion involved with motion simulation requirements than there is technical information. In fact, to a great extent, the research literature is deluged with studies intended to "prove a point" as opposed to obtaining valid information that is usable in defining training device requirements.

The air vehicle operates in a six degree-of-freedom of motion environment, three rotational and three translational (pitch, roll, yaw, vertical heave, longitudinal thrust, and lateral sway). Each of these degrees-of-freedom provides the pilots with additional information (real or illusory) as to the air vehicle's motion and position. This is evident by the fact that a simulator is easier to "fly" (better performance) when motion cues are provided. The problem is that this fact is quite independent of the question of training transfer effectiveness of various motion configurations. In fact, it is often the case in training situations that making a task more difficult than "real-life" results in more effective training (particularly with respect to retention). As to this date, there are no research results that allow one to make unquestioned decisions as to essentially any aspect of motion requirement

recommendations for the B-1 training system. Therefore, the recommendations described in the present section are a result of an analysis of the technical and research data (the Simulation Technology Assessment Report) and personal communication with many groups within the simulation community (see Appendix B, Technical Memorandum SAT-1, Vol. 3). These groups include both military and commercial training facilities, military and civilian research laboratories, simulator manufacturers, and military operational units.

If the question is posed, "is motion necessary?," the answer is "Yes and No!". The position one must adopt when establishing minimum (least costly) training device requirements is that the lowest complexity is assumed, with additional complexity requiring justification. However, there are logistical and economic factors which also play a part and must be considered in the process. These considerations are discussed throughout this section. Each degree-of-freedom of motion will be discussed in the context of meeting training objectives.

Roll acceleration is one of the pilots' motion inputs during both perturbing turbulance and normal operations. Roll position (bank) and roll rate are less important cues. Roll onset cues are provided primarily by cockpit motion, whereas rate and position are provided to the pilot, primarily through the visual channel (instruments and, if available, external scene). This is very much to the advantage of the training device designer. The use of washout-motion illustrates how the designer capitalizes on the human's "limitations."

Unlike roll, it is pitch position rather than pitch acceleration that is particularly important in the B-1. This is, to a great extent, due to the distance that the cockpit is in front of the air vehicle's center of gravity. Pitch changes, in this situation, are less apparent than the accompanying vertical acceleration when the air vehicle encounters a pitch change. Simulator pitch position is important during high pitch angle climbs to provide correct cue correlation between apparent gravity and the "air vehicles" attitude as presented on the instruments and the external visual scene.

The only time that yaw motion is an important cue is during malfunctions such as hard-over rudder SCAS failure or loss of engine power at low speed (e.g., take-off). The acceleration involved in these situations is relatively low (3 deg/sec^2; the air vehicle yaws 13 degrees in the first 3 seconds). This acceleration is near the human threshold for detecting yaw acceleration and is, in fact, below some of the yaw threshold values that are reported in the literature (see a review by Clark, 1967).

In addition, the response to these malfunctions is ballistic in nature, rather than precise control until the vehicle is retrimmed. A third consideration is that, at low frequency inputs, the visual simulation can provide the necessary cueing (alerting) function for these situations. For the preceding reasons, as well as the low difficulty in training these objectives, yaw is not justified as a requirement for Device 3/P/CP .

As previously mentioned, vertical acceleration (heave) results when rapid pitch changes are made as well as during actual rapid altitude changes

(e.g., terrain following and turbulence.) For this reason, heave is an important cue to the pilots, as well as introducing a detrimental environment such as encountered in turbulance. Therefore, heave is judged to be a requirement for Device 3/P/CP.

Lateral acceleration is primarily experienced in the same situation as yaw. This is primarily due to the distance between the cockpit and the center of gravity of the air vehicle (viz., 57.5 feet). In adopting the same rationale as previously described for the yaw degree-of-freedom, lateral motion does not appear to be an important cue for the purpose of training. Therefore, the lateral (sway) degree-of-freedom is not a requirement for Device 3/P/CP.

The last degree-of-freedom of motion is longitudinal thrust. Take-off and landing are the two major phases of flight in which thrust is a cue. In discussing the lack of thrust in the FB-111 simulation with SAC personnel, elicited comments were not negative regarding the training effectiveness of that device due to the lack of thrust. From this experience, and the low criticality of thrust-cued tasks, thrust is judged not to be a requirement for Device 3/P/CP.

Making use of the training objectives and the STAR document, the characteristics of a motion system (range, rate, and acceleration, respectively) that appear to satisfy the training requirements are as follows:

Pitch	-	+10 , -5 deg 10 deg/sec 25 deg/sec^2
Roll	-	±10 deg 10 deg/sec 25 deg/sec^2
Heave	-	± 1 ft 0.3 ft/sec 0.3 g
Payload	-	10,000 lbs

There are commercially available ("off-the-shelf") systems that meet these requirements.*

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* There is one aspect of motion system (as well as visual system requirements) that is important from a logistics aspect. It is advantageous for the Air Force to have standardized equipment for logistics purposes (repair and replacement of parts, technician training, etc.). Furthermore, there are essentially two categories of air vehicles in the Air Force: attack/fighter aircraft and bomber/cargo aircraft, each of which has different visual and cockpit motion requirements. Therefore, it is advantageous for the Air Force to have two standard motion base configurations. One of these systems would be a six-degree-of-freedom motion base to be used in fighter/attack training devices, while the other system would be a three degree-of-freedom motion base to be used in bomber/ cargo training devices.

Other forms of motion cueing that do not involve "cockpit" motion are the g-seats and g-suits. These devices can both accent the cockpit motion-base cues and provide long-term acceleration (sustained g). These devices are presently being evaluated; however, their effectiveness has not been established. Therefore, pending these evaluations, g-seats are tentatively recommended for Device 3/P/CP for the purposes of terrain following during low level, high speed flight.

The instructional features required within Device 3/P/CP are primarily concerned with performance measurement and assessment. That is, this device is a "practice" device rather than a "teaching" device. It is used to train the skills involved in air vehicle control which are tasks that require coordinated perceptual-motor behavior. Before entering this device, the trainee should have, within his repertoire of behaviors, all of the knowledges (enabling objectives) that are prerequisite to his developing the skill of vehicle control. Therefore, the primary instructional features involve automatic performance measurement for both on-line and summary trainee feedback, as well as training program evaluation and modification (see discussion preceding these device descriptions).

Another instructional feature involves the pre-programming of initial conditions, situations and events. Approximately ten different phases-of-flight/air vehicle configuration initial condition settings are required for Device 3/P/CP. In addition, approximately 200 events (e.g., malfunctions) or situations (e.g., air or ground threats) should be able to be pre-programmed, entered on-line by an instructor, or a combination of these two. These events must be capable of being programmed on the basis of both mission elapsed time and X, Y coordinates in the simulated space. The real complexity in the simulation of events and situations is in the software logic required to present realistic situations (e.g., combinations of malfunctions). Therefore, the problem of pre-programming is basically "logical," rather than technical. For this reason, the pre-programmed events and situations must be amenable to change.

Another feature which is presently proving effective in aircrew training is a complete flight profile record and playback system. The trainee's performance, along with the entire flight profile, is recorded with the capability of playing back the previous five-minute interval. This capability is required for both instroctor and trainee error analysis.

The final component of Device 3/P/CP is the instructor/operator station. This component is obviously closely related to the trainee performance monitoring and assessment capabilities previously discussed. There have been major advances in simulator instructor/operator console design in recent years. The concept of a "room-full" of repeater instruments is giving way to compact CRT alpha-numeric and graphics capabilities. This latter type of display system, in combination with general prupose and special function keyboards for data acquisition, allows a large amount of versatility with low space requirements.

3.3.4.2 Device 3/OSO Part-Mission Trainer

The primary phases of flight for which the OSO training objectives require high-fidelity, real-time, interactive training device capabilities are: high-level navigation (high and low speed); low-level navigation (high and low speed); aerial refueling; high-level weapons delivery; low-level weapons delivery; terrain following; and instrument landing approaches. The training objectives concerned with these flight phases require "high-fidelity" landmass, navigation systems, and weapons delivery simulation. A term that is often applied to devices with similar capabilities is "avionics trainer."

The offensive systems simulation for the B-1 can be grouped into six "component" systems. These are:

1) Navigation Systems (e.g., inertial and doppler).

2) Attack Radar (e.g., landmass).

3) Stores Management System (e.g., conventional, nuclear, and SRAM weapons).

4) Central Integrated Test System (shared with DSO).

5) Logic Trees (integrated keyboard)

6) Forward-Looking Infrared.

The navigation systems in the B-1 are essentially the same as those being used in similar SAC air/vehicles (e.g., FB-111). Therefore, the simulation characteristics used in the FB-111 navigation systems appear to be appropriate for Device 3/OSO.

The Strategic Air Command (SAC) mission of the B-1 is an important consideration for the radar simulation requirements. The corridor of operation for a SAC mission is relatively small. That is, for an EWO mission, the "extent" (maneuvering) allowed laterally and in altitude are well-defined in that the air vehicle should be on-track and should maintain the desired altitude plus or minus a small amount. Performance outside of these limits does not meet the criterion and is not acceptable. The implications of the restricted corridor for B-1 operation is that it is costly and useless to carry the radar landmass simulation beyond these limits. The trade-off to be made in this situation is to provide more longitudinal (track) extent at the expense of lateral extent.

Another consideration of importance in radar landmass simulation is the placement of the high resolution (landmass data) where it is needed. For example, the resolution required for high altitude flight phases is much lower than the resolution needed for low altitude flight; however, even greater resolution then both may be needed in the target area. Great savings can be obtained by analyzing both the training and emergency war order (EWO) missions in the determination of the needed resolution of the landmass simulation. The resolution of the data base need not exceed the resolution of the actual radar system with the appropriate range setting for a particular phase of the mission.

For the purposes of training, as well as some parts of EWO mission rehearsal, the use of "generic" landmass (and maps) rather than "actual" landmass can result in cost savings without reducing training effectiveness. Through modeling techniques, it is possible to produce appropriate landmass and cultural features that can enhance the training effectiveness of the attack radar simulation. A third alternative is a combination of generic and actual landmass, in which selected actual features are superimposed on generic landmass. Because of the great amount of ground that is covered during B-1 operations (much of which is irrelevant), this third alternative has great utility for B-1 training.

There are two major approaches to landmass data base storage. One is the use of a film plate system, the second uses digital computer storage. These approaches, their respective advantages, and problems are discussed in the Simulation Technology Assessment Report. Basically, the situation is that there recently has been (and will apparently continue to be) a significant investment in research and development for digital radar landmass (DRLM) with little financial support being given to the photographic approach. As a result, the state-of-the-art in digital radar landmass is more advanced than the state-of-the-art in photographic techniques. For these reasons, DRLM is recommended for Device 3/OSO.

The simulation of the B-1 Stores Management System (SMS), as with the navigation system, is presently being simulated effectively in other air vehicle systems. The approaches being used in these simulations appear to be appropriate for the Device 3/OSO.

The Central Integrated Tests System (CITS) tests and displays malfunction information to the crew. The displays consist of switch lights and alphanumerics presented on Cathode Ray Tubes (CRT). The real complexity in the simulation of "malfunction insertion and manipulation" is one of the areas of simulation that has generally received far too little attention. The simulation of malfunctions requires extensive analysis of the possible contingencies and their probabilities. To this extent, the problems in CITS simulation are "logical " rather than technical. It is recommended that procurement of this component be augmented by suitable analyses to be carried out before the malfunctions are determined.

The logic trees utilized in conjunction with the integrated keyboard (IKB) involve alphanumeric displays (or CRT's) and keyboard controls. An important aspect of the simulation of this component is to ensure that the simulation is easily updated so that the simulation accurately represents the latest updates of the software program in the air vehicle.

The last offensive system "component" is the forward-looking infrared system (FLIR). As previously discussed, simulation of FLIR in a real-time, interactive mode is a problem within the present simulation state-of-the-art. Due to the fact that most FLIR training can occur in a non-interactive mode (e.g., FLIR interpretation and target detection), interactive simulation of FLIR appears to be unnecessary. Interactive FLIR training is accomplished in airborne training instructional blocks. This should not increase flight time since the training is short in duration and not high in criticality.

No training objective for the OSO illustrated the requirement for cockpit motion for Device 3/OSO. That is bodily motion is not an important cue to the OSO. This result is in concurrence with the experience gained by other systems operators training programs (e.g., S-3A). The only aspect of motion that affects the OSO is the disruptive (task-loading) effects (e.g., buffeting). In the situations where task-loading is a contributer to training effectiveness, it can be accomplished at much less expense (procurement and O&M) by other means (e.g., malfunction insertion).

The instructional features required within Device 3/OSO are essentially the same as those included in Device 3/P/CP (see previous subsection). Similarly, the instructor/operator stations are similar.

It is possible, with this configuration, to utilize an instructor console within the trainer cockpit. This allows rapid instructor feedback to the trainee and subsequent real-time training sortie modification on the basis of the trainee's motor behavior. A format that is effective in instructor-simulator-trainee interactions is a combination of graphical representation of actual and desired trainee performance (e.g., lower third of the display) and an alphanumeric presentation for data entry and access (e.g., event occurances, mission sortie synopsis). A logic-tree organization for data entry and access is recommended. The insertion of data and requests utilizes two special function keyboards and one general purpose keyboard. One of the special function keyboards has 16 keys (4 x 4) and is used for most frequently used malfunction insertions (including pre-programmed realistic combinations of malfunctions). The second special function keyboard has nine keys (9 x 1) and is used to access data through the logic trees displayed on the CRT. The third input device is a general purpose keyboard that is used for data insertion and access of less likely malfunctions. This arrangement allows a great amount of versatility in the system while ensuring rapid interaction between the instructor, simulator, and trainee.

A similar configuration is recommended for an instructor/operator console external to the trainer cockpit. This console should be capable of operating two Device 3/P/CP cockpits. The configuration involving the instructor being at an external console is particularly useful during later taining (advanced practice) when the trainee's demands on the instructor's vigilance is significantly reduced. As one additional feature of Device 3, the facilities plan (Section 4) is allowing for direct entrance of the trainees to their work station without walking past the computer or instructur's consoles. By so doing, an attempt is being made to reduce the artificiallity of the setting, so as to increase the involvement of the trainees in their training environment.

3.3.4.3 Device 3/DSO Part-Mission Trainer

This device is an electronic warfare simulation used for training the Defensive Systems Operator (DSO) on real-time ECM tasks. The primary components of this device are various data input (and acquisition) keyboards, panoramic (frequency spectrum) display, threat situation display, alphanumeric display, and a cursor control. As with Device 2/DSO, a detailed description of this

device is dependent upon the conduction of an analysis of the DSO tasks. As was discussed in the Simulation Technlogy Assessment Report, this trainer is expected to be within the present state-of-the-art in simulation. The instructor stations and automatic performance measurement and pre-programming capabilities are anticipated to be functionally similar to the 3/OSO trainer.

3.3.4.4. On-board Computer

The B-1 air vehicle contains a number of on-board computers much of whose capabilities must be included in Device 3. In the course of this study, an examination was made of the various means for providing this capability. These include:

1. Duplication of airborne equipment;

2. Evaluation - incorporation of the Operational Flight Program (OFP) as a subroutine of the various training devices computers with interfacing models to provide the instructional requirements;

3. Simulation of airborne equipment.

The choice among them depends upon trade-off decisions related to the allocation of functions within the OFP and the impact on the training devices of revisions to the OFP. Recommendations cannot be made at this time, but a more complete assessment of the problem is the subject of B-1 SAT Management Memo MMSAT-20 (Software Support of Trainees; WFHRing; 6 June 1975).

3.3.5 Device 4 - Full Mission Trainer

This device is a total-crew trainer that provides crew coordinated practice of the mission. The OSO and DSO stations of this device are the same as Device 3/OSO and 3/DSO, with the addition of an interface between the trainers to provide interaction capabilities.

The front station (pilot and copilot) of this device is similar to the Device 3/P/CP, with the addition of the same systems not included in the previously described device (e.g., weapons (e.g., weapons systems) and the interface with the OSO and DSO stations.

This device can be utilized in both an integrated-crew mode or a crew member-independent mode (e.g., OSO and DSO, practicing interactively with the front station being totally independent). The instructors' station incorporates up to three instructors (OSO, DSO and Pilot) that work either in a coordinated manner (crew interacting) or independently (crew not interacting).

As with the Device 3s, this trainer incorporates automatic performance measurement, performance record and playback, and pre-programmed mission capabilities. The purpose of this device is for the practice and evaluation of the entire crew on an emergency war order (EWO) mission.

3.4 PREFERRED INSTRUCTIONAL SYSTEM DESIGN

The first two steps in the process of SAT (analysis of the operational mission and identification of behavioral objectives) are means to the end product. The end product is an effective training system of least cost. One aspect of this training program is the devices and facilities required. The devices were introduced in the preceding paragraphs, while the facility requirements are described in the next section. A second aspect of the program is the sequence of instructional blocks that make up the course syllabi. This sequencing of blocks is based on both learning principles and effective resource (device) utilization.

3.4.1 Instructional Strategy

The guidelines provided within the principles of learning that generally pertain across the spectrum of training objectives are the basis for organizing instructional block sequences. One of these guidelines that has previously been introduced in the preceding section is active participation by the trainee. This "early hands-on" philosophy results in both superior training effectiveness, as well as increased trainee attention and motivation (which is obviously correlated with training effectiveness). The implementation of this guideline illustrates the interactiveness of training objectives, training device requirements, and instructional block sequencing. To incorporate hands-on training, while ensuring that device capability is not under-utilized during the various stages of training, a spectrum of devices is required as described in the previous section. That is, the fidelity required during early training is often less than that required for later training, and the use of a complex device in the former case is not cost-effective.

A second principle that is well-established in the literature of learning theory is that acquisition of new information is facilitated when that new information is associated with previously-learned concepts. The general result of adhering to this principle is that a context is provided within which the new information becomes more meaningful. A term used within the SAT methodology which is associated with this principle is the enabling objectives hierarchy discussed in Section 2.1.7.3. Again, this principle has implication with respect to device utilization. Prerequisite (enabling) skills and knowledges are usually acquired individually in simple devices and are later integrated into the more complex skill in a more complex device. In the context of aircrew training, this often takes the form of increased difficulty due to task loading.

Another guideline that results in increased trainee motivation and, thereby increased training effectiveness, is spaced practice (as opposed to massed practice). This guideline pertains to both material and devices. That is, trainee boredom can result from a long exposure to the same material or a long period of time in the same device.

Three operational characteristics of training objectives also play a part in the determination of instructional block duration and sequencing. These factors are: (1) difficulty, (2) criticality, and (3) probability of occurrence. There are two aspects of objective difficulty: difficulty to perform the behavior and difficulty to learn the behavior. These two are often correlated, although they are often quite independent. Both of these aspects of difficulty must be taken into account in developing course content.

The four crewmembers of the B-1 air vehicle are components of the entire B-1 weapons system. As with any component of a weapons system, the crewmember has associated with him a "reliability". The purpose of a training program is to increase the reliability of the crewmember component. This increase in reliability can be costly, and must be evaluated (as with other components) as to whether the increase warrants the cost. It is during this evaluation that the difficulty, criticality, and probability factors are important. For example, the criticality of a training objective influences the training time in that if an objective (e.g., engine failure emergency procedure) has high criticality with respect to accomplishing the mission, training time must be sufficient to ensure that the trainee can accomplish the mission. On the other hand, if the objective is not critical (no impairing effect on the mission),then less training time is justified.

As in the evaluation of any component's reliability, the probability of an event occurring is important in deciding whether additional expense is justified to increase the probability of handling that event. Training of aircrew members is no different. If the probability of the event is "high", the behavior required to handle the event must be trained and the time allocated for training that behavior must be sufficient. It is obvious that the criteria for when the probability and criticality are "high" is ill-defined. The cooperative judgment of operational personnel and training specialists must be used to make decisions of this type. One of the often-cited purposes of including a human in a system, as opposed to total automation, is the human's ability to adapt and handle situations (events) that have not been previously encountered. A training program that attempts to exhaustively train on all possible (low probability) situations is disregarding the crewmembers' inherent capabilities.

3.4.2 Airborne and Ground Training Limitations

There are a number of situations that cannot be encountered during training in the air vehicle but can be simulated in training devices. The most recognized areas in which the air vehicle is limited, relative to simulation, is in emergency situations that are potentially hazardous to the air vehicle as well as the crew (e.g., engine failure on take-off). These situations can be simulated in the training devices while monitoring safety requirements.

A second, and related, area in which simulation is the only feasible approach is the training for equipment malfunctions that may jeopardize the safety of the crew. Although this is a somewhat less obvious aspect of flight vs. simulation, it is an important concern.

An external influence that has severe implications for in-flight training is the limitation of air space. For example, there is a limited number of low-altitude/high-speed (e.g., olive branch) routes available for training. This limitation has been evaluated in the B-1 SAT program and the recommendations are consistent with the present (1975) air space limitations (Military Training Routes, 11 Sept., 1975).

Another advantage of training devices that cannot be achieved in training flights is a realistic combat (EWO) environment. The case of electronic warfare training is a prime example of this. Simulation is far superior to flight for presenting a trainee with realistic ECM (threat) scenarios. Similarly, as discussed in a previous section, simulated landmass can be manipulated to result in effective OSO training on a multitude of landmass characteristics that is difficult to achieve with "real" landmass.

A final aspect of training in ground-based devices rather than in-flight is the advantage of the instructional features. For example, the ability to "freeze" the flight situation (problem) for instruction has great utility. Similarly, the performance recording and on-line playback is very effective for trainee feedback.

Due to the previously mentioned limitations of airborne as opposed to ground trainer instruction and the early "hands-on" use of the complex devices (e.g., Device 3), these devices must be operational for instructor training two months prior to the first trainee entry date. This lead time for instructor training on the devices is very important for effective utilization of the device capabilities.

The course structures, to be described next, have made maximum use of the synthetic training capabilities of the training devices (described earlier). The essential training of skills and knowledges takes place in the least costly device possible, with practice taking place in the more sophisticated devices. In the course structures, the B-1 is used primarily as the "ultimate" practice device. The only skill/knowledge that is acquired primarily in the B-1 are those related to the real-time, interactive aspects of the FLIR System (see Section 3.3.4).

3.4.3 Basic Structure of the Courses

3.4.3.1 Combat Crew Training School (CCTS) Instructional Block Sequence

Aircrews on vehicles such as the B-1 are more "systems operators" today than in air vehicles of the past. The training programs reflect this change. The basic structure of the proposed training program is one of "systems within phase-of-flight". That is, many systems (or subsystems) are specific to phase-of-flight (e.g., refueling and weapons delivery) while others cut across phases-of-flight (e.g., electrical). Malfunction of this latter group of systems, however, are often specific to phases-of-flight.

The concept of systems within phase-of-flight is consistent with the previously mentioned learning guidelines (e.g., building associations on the basis of context).

There are four courses included at the CCTS (pilot, copilot, OSO, and DSO). Within each of these courses, there are "tracks" that result from differing trainee entry level abilities which derive from their source of training and experience prior to B-1 assignment. There are a total of ten tracks at the CCTS within the four courses (Table 3). Sources are not exclusively those shown. These tracks will accept any trainee of comparable experience.

Table 3 Definition of Tracks

Course	Track	Source (typical)
Pilot	A	FB-111 pilot
	B	B-52 pilot
	C	KC-135 pilot
Copilot	D	B-52 copilot
	E	Undergraduate Pilot Training (UPT)
OSO	F	FB-111 Navigator
	G	B-52 Navigator/bombadier
	H	Undergraduate Navigator Training (UNT)
DSO	I	B-52 Electronic Warfare Officer
	J	Electronic Warfare Officer Training (EWOT)

The sequencing of the instructional blocks which make up the syllabi for the Preferred Instructional System (excluding the DSO) is presented in Figure 11. This example shows a series of three instructional blocks for Track 1 and two

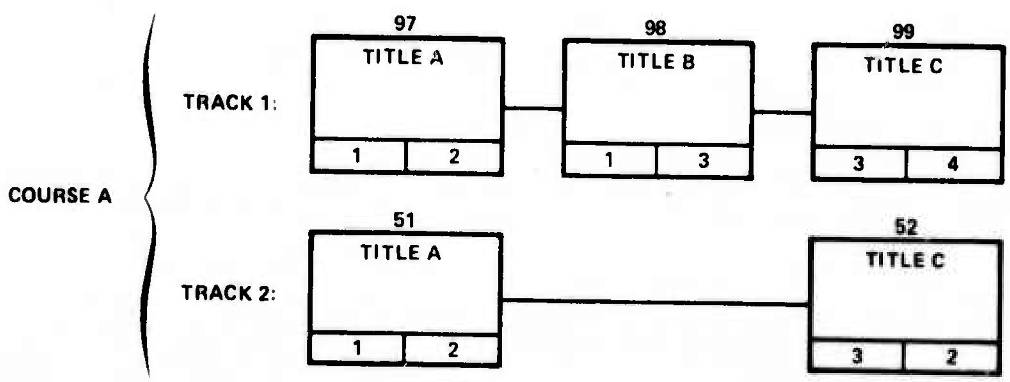

Figure 11 SAMPLE INSTRUCTIONAL BLOCK SEQUENCE

blocks for Track 2. On top of each block is its designating number. Within the block are written the block title, training device (lower left), and time in hours (lower right). The training device is the one appropriate to the track (e.g., Device 3 for a copilot track refers to Device 3/P/CP). The first two blocks of both tracks are identical. The Track 2 individuals do not go through the second block of Track 1. The last block involves the same subject matter, but Track 2 needs less time due to an increased level of incoming knowledge. Blocks that involve the same subject matter are lined up vertically across pilot and copilot tracks and across OSO tracks.

For convenience in preparing this chart, the instructional blocks within each track were numbered sequentially and independently of the other tracks. Consequently, blocks in different tracks, but having the same block number, usually do not have related content.

An instructional strategy was employed with regard to crew coordination in which some blocks are "correlated" and some are "synchronized." Correlation occurs between pilot and copilot blocks when the content of analogous blocks requires coordinated participation of both crew members. In earlier stages of training, the particular pairing of a pilot/copilot team is irrelevant. In these cases, each is paired with any (or the next) available partner. This scheme allows one instructor to supervise two trainees rather than to use the instructor as a surrogate crew member while supervising only one trainee. In later stages of training, the coordinated practice of a particular entire crew becomes important to lessen the effects of idiosyncracies that can disrupt the smoothness of a crew's operations when one or more "strangers" are put together. To achieve crew coordination, the last blocks for all tracks are synchronized. That is, for a period of time before graduation, a crew is formulated that then stays together during the end of their CCTS training and who are then assigned as a crew to a Main Operating Base (MOB). Correlations are indicated in Figure 12 by a C in the dividing space between the Pilot and Copilot tracks (no correlations exist with OSO and DSO tracks). With two exceptions, all synchronized blocks are merged into one track at the appropriate point (last two pages of the chart). Again, for convenience, this final synchronization track is consecutively numbered independently of the other tracks. In two cases, before the trainees reach the Synchronization Phase, synchronized blocks occur in which the crew (the same members to be matched up later) comes together for coordinated training for the first and second time. The blocks of the first instance are designated by a single asterisk next to the instructional block number; the second is marked by a double asterisk on the particular block in each track. These blocks are among those in which Devices 2/P/PC, 2/OSO, and 2/DSO are linked by communications so that coordinated practice can take place.

It should be noted, as discussed at various points in this report, that the actual sequencing depends on a number of factors, including learning strategy. In the process of refining the courses, the ISD team will have the prerogative of interchanging blocks and altering their content to achieve

more efficient learning and/or scheduling of students and resources. (In fact, the placement of some of the instructional blocks requiring early synchronization was done on this basis of scheduling to avoid introducing waiting periods prior to the crew rejoining at the ends of their courses.)

An important consideration in the use of the various training devices to satisfy behavioral objectives is the symmetry of the B-1 front station instrumentation. That is, relationship of the controls and displays for both the pilot and the copilot are in essence, identical (e.g., throttle levers). Therefore, it is possible to practice most pilot and copilot tasks in either the left or right seat of Devices 2,3, and 4. This capability results in greater versatility in scheduling (e.g., pairing of pilots or of copilots for Device 2,3, and 4 sessions).

Table 4 summarizes the major features of the CCTS courses relevant to device utilization and total nominal contact hours per track. In addition to Devices 0,1,2,3, and 4, the table also lists hours in briefing rooms, in airborne training, and ground use of B-1 air vehicles.

Closely associated with the Instructional Block chart (Figure 12) is the listing (Table 18) of those instructional blocks within which the criteria of each Behavioral Objective is first attained. Table 18 is included as Section 6 of this volume. For each Behavioral Objective (cf. Technical Memorandum SAT-2), the instructional block is listed (for each track) which satisfies the requirements of that objective. Later blocks, of course, may re-evaluate that objective in conjunction with other objectives. Earlier blocks provide the enabling skills and knowledges required to later achieve the Behavioral Objectives. The Instructional Block chart (Figure 12) follows.

Table 4

CCTS SUMMARY TABLE OF COURSE DURATIONS (HOURS) BY TRAINING DEVICE

COURSE	PILOT			CO-PILOT		OSO			DSO[2]	
TRACK[1]	A	B	C	D	E	F	G	H	I	J
DEVICE										
BRIEFING	89	96	108	96	96	76	81	89	97	107
0 – CARREL	43	40	68	40	68	78	84	110	50	60
1 – FAMILIARIZATION	31	43	48	43	48					
2 – PROCEDURES	36[3]	40[3]	40[3]	40[3]	40[3]	81	84	86	40	50
3 – PART-MISSION	29	37	48	37	37	24	35	50	50	65
4 – FULL-MISSION	21	21	21	21	21	21	21	21	21	21
B1	27	27	33	27	27	21	21	21	21	21
TOTAL	276	304	366	304	337	301	326	377	279	324

[1]TYPICAL SOURCE OF TRAINEES

[2]PRELIMINARY ESTIMATES ONLY

[3]INCLUDES 2 HOURS IN DEVICE 2/OSO

FIGURE 12

INSTRUCTIONAL BLOCKS
(Pages 54 - 79)

ABBREVIATIONS FOR FIGURE 12

A/C	Aircraft
ACU	Avionics Control Unit
AFCS	Automatic Flight Control System
Alt Proc	Alternative Procedures
APU	Auxiliary Power Unit
AR	Aerial Refueling
ATF	Automatic Terrain Folliwing
Aux Nav	Auxiliary Navigation
CITS	Central Integrated Test System
c.g.	Center of Gravity
conv	Conventional
DR	Dead Reckoning
ECM	Electronic Countermeasures
EVS	Electro-Optical Viewing System
FLIR	Forward Looking Infra-Red
FLR	Forward Looking Radar
ICS	Intercom System
IKB	Integrated Keyboard
INS	Inertial Navigation System
IP	Initial Point
jett	Jettison
Ldg	Landing
MTF	Manual Terrain Following
Nav	Navigation
Nuc.	Nuclear
PIP	Pre-Initial Point
SCAS	Stability and Control Augmentation System
SMCS	Structural Mode Control System
SMS	Stores Management System
TF	Terrain Following
TFR	Terrain Following Radar
TO	Take-Off
VSD	Vertical Situation Display
X-Hair	Cross Hair

B-1 COURSE	CCTS TRACK	1	2	3	4
PILOT	A	MANUALS ISSUE DEV B | 2 HR	AIRCRAFT ORIENTATION DEV O | 4 HR	FAMILIARIZATION W/ FLIGHT INSTRUMENTS & CONTROLS DEV 1 | 2 HR	DEVICE 3 ORIENTATION & PRACTICE DEV 3 | 2 HR
PILOT	B	MANUALS ISSUE DEV B | 2 HR	AIRCRAFT ORIENTATION DEV O | 4 HR	FAMILIARIZATION W/ FLIGHT INSTRUMENTS & CONTROLS DEV 1 | 2 HR	DEVICE 3 ORIENTATION & PRACTICE DEV 3 | 2 HR
PILOT	C	MANUALS ISSUE DEV B | 2 HR	AIRCRAFT ORIENTATION DEV O | 4 HR	FAMILIARIZATION W/ FLIGHT INSTRUMENTS & CONTROLS DEV 1 | 2 HR	DEVICE 3 ORIENTATION & PRACTICE DEV 3 | 2 HR
COPILOT	D	MANUALS ISSUE DEV B | 2 HR	AIRCRAFT ORIENTATION DEV O | 4 HR	FAMILIARIZATION W/ FLIGHT INSTRUMENTS & CONTROLS DEV 1 | 2 HR	DEVICE 3 ORIENTATION & PRACTICE DEV 3 | 2 HR
COPILOT	E	MANUALS ISSUE DEV B | 2 HR	AIRCRAFT ORIENTATION DEV O | 4 HR	FAMILIARIZATION W/ FLIGHT INSTRUMENTS & CONTROLS DEV 1 | 2 HR	DEVICE 3 ORIENTATION & PRACTICE DEV 3 | 2 HR
OSO	F	MANUALS ISSUE DEV B | 2 HR	AIRCRAFT ORIENTATION DEV O | 4 HR	GENERAL AVIONICS ORIENTATION DEV 0 | 2 HR	
OSO	G	MANUALS ISSUE DEV B | 2 HR	AIRCRAFT ORIENTATION DEV O | 4 HR	GENERAL AVIONICS ORIENTATION DEV 0 | 2 HR	
OSO	H	MANUALS ISSUE DEV B | 2 HR	AIRCRAFT ORIENTATION DEV O | 4 HR	GENERAL AVIONICS ORIENTATION DEV 0 | 2 HR	

5	6	7	8	9
DEBRIEFING	A/C FLIGHT CHARACTERISTICS	FLIGHT AND ENGINE INSTRUMENTS	VSD ORIENTATION & SYMBOLOGY	PRIMARY FLIGHT CONTROLS (SCAS, SMCS)
DEV B / 1 HR	DEV 0 / 2 HR	DEV 1 / 2 HR	DEV 0 / 2 HR	DEV 1 / 3 HR

5	6	7	8	9
DEBRIEFING	A/C FLIGHT CHARACTERISTICS	FLIGHT AND ENGINE INSTRUMENTS	VSD ORIENTATION & SYMBOLOGY	PRIMARY FLIGHT CONTROLS (SCAS, SMCS)
DEV B / 1 HR	DEV 0 / 2 HR	DEV 1 / 6 HR	DEV 0 / 2 HR	DEV 1 / 6 HR

5	6	7	8	9
DEBRIEFING	A/C FLIGHT CHARACTERISTICS	FLIGHT AND ENGINE INSTRUMENTS	VSD ORIENTATION & SYMBOLOGY	PRIMARY FLIGHT CONTROLS (SCAS, SMCS)
DEV B / 1 HR	DEV 0 / 2 HR	DEV 1 / 6 HR	DEV 0 / 2 HR	DEV 1 / 6 HR

5	6	7	8	9
DEBRIEFING	A/C FLIGHT CHARACTERISTICS	FLIGHT AND ENGINE INSTRUMENTS	VSD ORIENTATION & SYMBOLOGY	PRIMARY FLIGHT CONTROLS (SCAS, SMCS)
DEV B / 1 HR	DEV 0 / 2 HR	DEV 1 / 6 HR	DEV 0 / 2 HR	DEV 1 / 6 HR

5	6	7	8	9
DEBRIEFING	A/C FLIGHT CHARACTERISTICS	FLIGHT AND ENGINE INSTRUMENTS	VSD ORIENTATION & SYMBOLOGY	PRIMARY FLIGHT CONTROLS (SCAS, SMCS)
DEV B / 1 HR	DEV 0 / 2 HR	DEV 1 / 6 HR	DEV 0 / 2 HR	DEV 1 / 6 HR

4	5	6
FLR X-HAIR CONTROL SWITCHES	FLR X-HAIR CONTROL & TRACKING	FLR X-HAIR CONTROL & TRACKING
DEV 0 / 1 HR	DEV 2 / 2 HR	DEV 3 / 2 HR

4	5	6	7	8
FLR X-HAIR CONTROL SWITCHES	FLR X-HAIR CONTROL & TRACKING	FLR X-HAIR CONTROL & TRACKING	FLR ORIENTATION	FLR TUNE UP
DEV 0 / 1 HR	DEV 2 / 2 HR	DEV 3 / 2 HR	DEV 0 / 2 HR	DEV 0 / 1 HR

4	5	6	7	8
FLR X-HAIR CONTROL SWITCHES	FLR X-HAIR CONTROL & TRACKING	FLR X-HAIR CONTROL & TRACKING	FLR ORIENTATION	FLR TUNE UP
DEV 0 / 1 HR	DEV 2 / 2 HR	DEV 3 / 2 HR	DEV 0 / 2 HR	DEV 0 / 2 HR

	10	11	12	13	14
A	SECONDARY FLIGHT CONTROLS — DEV 1 — 2 HR	COMMUNICATION/ NAVIGATION — DEV 1 — 2 HR	PERFORMANCE/ MISSION PLANNING (TO, LDG) — DEV 0 — 1 HR	BRIEFING/ DEBRIEFING — DEV B — 1 HR	TO, LDG. PRACTICE — DEV 3 — 2 HR
B	SECONDARY FLIGHT CONTROLS — DEV 1 — 3 HR	COMMUNICATION/ NAVIGATION — DEV 1 — 2 HR	PERFORMANCE/ MISSION PLANNING (TO, LDG) — DEV 0 — 1 HR	BRIEFING/ DEBRIEFING — DEV B — 1 HR	TO, LDG. PRACTICE — DEV 3 — 2 HR
C	SECONDARY FLIGHT CONTROLS — DEV 1 — 3 HR	COMMUNICATION/ NAVIGATION — DEV 1 — 4 HR	PERFORMANCE/ MISSION PLANNING (TO, LDG) — DEV 0 — 1 HR	BRIEFING/ DEBRIEFING — DEV B — 1 HR	TO, LDG. PRACTICE — DEV 3 — 2 HR
				(C)	(C)
D	SECONDARY FLIGHT CONTROLS — DEV 1 — 3 HR	COMMUNICATION/ NAVIGATION — DEV 1 — 2 HR	PERFORMANCE/ MISSION PLANNING (TO, LDG) — DEV 0 — 1 HR	BRIEFING/ DEBRIEFING — DEV B — 1 HR	TO, LDG. PRACTICE — DEV 3 — 2 HR
E	SECONDARY FLIGHT CONTROLS — DEV 1 — 3 HR	COMMUNICATION/ NAVIGATION — DEV 1 — 4 HR	PERFORMANCE/ MISSION PLANNING (TO, LDG) — DEV 0 — 1 HR	BRIEFING/ DEBRIEFING — DEV B — 1 HR	TO, LDG. PRACTICE — DEV 3 — 2 HR
F					

	9	10	11	12	13
G	FLR TUNE UP — DEV 2 — 1 HR	FLR · RANGE AZIMUTH, ANTENNA TILT — DEV 0 — 2 HR	FLR · RANGE, AZIMUTH — DEV 2 — 1 HR	FLR · TUNING, RANGE, AZIMUTH — DEV 3 — 2 HR	DEBRIEFING — DEV B — 1 HR
H	FLR TUNE UP — DEV 2 — 2 HR	FLR · RANGE AZIMUTH, ANTENNA TILT — DEV 0 — 2 HR	FLR · RANGE, AZIMUTH — DEV 2 — 1 HR	FLR · TUNING, RANGE, AZIMUTH — DEV 3 — 2 HR	DEBRIEFING — DEV B — 1 HR

15	16	17	18	19
HYDRAULIC SYSTEM	LANDING GEAR & BRAKES	PRIMARY FLIGHT CONTROLS (ALT. PROC., SCAS FAILURES)	PRIMARY FLIGHT CONTROLS (ALT. PROC., SCAS FAILURES)	SECONDARY FLIGHT CONTROLS (ALT. PROC.)
DEV 1 | 1 HR	DEV 1 | 1 HR	DEV 1 | 2 HR	DEV 2 | 2 HR	DEV 1 | 1 HR

15	16	17	18	19
HYDRAULIC SYSTEM	LANDING GEAR & BRAKES	PRIMARY FLIGHT CONTROLS (ALT. PROC., SCAS FAILURES)	PRIMARY FLIGHT CONTROLS (ALT. PROC., SCAS FAILURES)	SECONDARY FLIGHT CONTROLS (ALT. PROC.)
DEV 1 | 1 HR	DEV 1 | 1 HR	DEV 1 | 2 HR	DEV 2 | 2 HR	DEV 1 | 1 HR

15	16	17	18	19
HYDRAULIC SYSTEM	LANDING GEAR & BRAKES	PRIMARY FLIGHT CONTROLS (ALT. PROC., SCAS FAILURES)	PRIMARY FLIGHT CONTROLS (ALT. PROC. SCAS FAILURES)	SECONDARY FLIGHT CONTROLS (ALT. PROC.)
DEV 1 | 1 HR	DEV 1 | 1 HR	DEV 1 | 2 HR	DEV 2 | 2 HR	DEV 1 | 1 HR

(C)

15	16	17	18	19
HYDRAULIC SYSTEM	LANDING GEAR & BRAKES	PRIMARY FLIGHT CONTROLS (ALT. PROC., SCAS FAILURES)	PRIMARY FLIGHT CONTROLS (ALT. PROC., SCAS FAILURES)	SECONDARY FLIGHT CONTROLS (ALT. PROC.)
DEV 1 | 1 HR	DEV 1 | 1 HR	DEV 1 | 2 HR	DEV 2 | 2 HR	DEV 1 | 1 HR

15	16	17	18	19
HYDRAULIC SYSTEM	LANDING GEAR & BRAKES	PRIMARY FLIGHT CONTROLS (ALT. PROC., SCAS FAILURES)	PRIMARY FLIGHT CONTROLS (ALT. PROC., SCAS FAILURES)	SECONDARY FLIGHT CONTROLS (ALT. PROC.)
DEV 1 | 1 HR	DEV 1 | 1 HR	DEV 1 | 2 HR	DEV 2 | 2 HR	DEV 1 | 1 HR

7	8		9	10
ICS & LIGHTING	PERFORMANCE/ MISSION PLANNING		PRESENT POSITION, SELECTED POINT STEER (NAV PANEL)	PRESENT POSITION, SELECTED POINT, STEER (NAV. PANEL)
DEV 0 | 1 HR	DEV 0 | 2 HR		DEV 2 | 1 HR	DEV 3 | 2 HR

14	15	16	17	18
ICS & LIGHTING	PERFORMANCE/ MISSION PLANNING	PRESENT POSITION SELECTED POINT, STEER (NAV. PANEL)	PRESENT POSITION, SELECTED POINT STEER (NAV. PANEL)	PRESENT POSITION, SELECTED POINT, STEER (NAV. PANEL)
DEV 0 | 1 HR	DEV 0 | 2 HR	DEV 0 | 2 HR	DEV 2 | 2 HR	DEV 3 | 3 HR

14	15	16	17	18
ICS & LIGHTING	PERFORMANCE/ MISSION PLANNING	PRESENT POSITION SELECTED POINT, STEER (NAV PANEL)	PRESENT POSITION, SELECTED POINT STEER (NAV. PANEL)	PRESENT POSITION, SELECTED POINT, STEER (NAV. PANEL)
DEV 0 | 1 HR	DEV 0 | 2 HR	DEV 0 | 2 HR	DEV 2 | 2 HR	DEV 3 | 3 HR

A	20 SECONDARY FLIGHT CONTROLS (ALT. PROC.) — DEV 2, 2 HR			21 CITS — DEV 2/OSO, 2 HR	22 FIRE WARNING SYSTEM — DEV 1, 1 HR
B	20 SECONDARY FLIGHT CONTROLS (ALT. PROC.) — DEV 2, 2 HR	21 BRIEFING/ DEBRIEFING — DEV B, 1 HR	22 TO, LDG., FLIGHT CONTROL EMERGENCIES — DEV 3, 2 HR	23 CITS — DEV 2, 2 HR	24 FIRE WARNING SYSTEM — DEV 1, 1 HR
C	20 SECONDARY FLIGHT CONTROLS (ALT. PROC.) — DEV 2, 2 HR	21 BRIEFING/ DEBRIEFING — DEV B, 1 HR	22 TO, LDG., FLIGHT CONTROL EMERGENCIES — DEV 3, 2 HR	23 CITS — DEV 2, 2 HR	24 FIRE WARNING SYSTEM — DEV 1, 1 HR
	(C)	(C)	(C)		
D	20 SECONDARY FLIGHT CONTROLS (ALT. PROC.) — DEV 2, 2 HR	21 BRIEFING/ DEBRIEFING — DEV B, 1 HR	22 TO, LDG., FLIGHT CONTROL EMERGENCIES — DEV 3, 2 HR	23 CITS — DEV 2, 2 HR	24 FIRE WARNING SYSTEM — DEV 1, 1 HR
E	20 SECONDARY FLIGHT CONTROLS (ALT. PROC.) — DEV 2, 2 HR	21 BRIEFING/ DEBRIEFING — DEV B, 1 HR	22 TO, LDG., FLIGHT CONTROL EMERGENCIES — DEV 3, 2 HR	23 CITS — DEV 2, 2 HR	24 FIRE WARNING SYSTEM — DEV 1, 1 HR
F	11 IKB ORIENTATION — DEV 0, 2 HR	12 IKB - NAV COURSE SELECT — DEV 0, 1 HR	13 IKB - NAV COURSE SELECT — DEV 2, 2 HR	14 EJECTION SEAT & EGRESS — DEV 0, 2 HR	15 INS, DOPPLER, DR — DEV 0, 2 HR
G	19 IKB ORIENTATION — DEV 0, 2 HR	20 IKB - NAV COURSE SELECT — DEV 0, 1 HR	21 IKB - NAV COURSE SELECT — DEV 2, 2 HR	22 EJECTION SEAT & EGRESS — DEV 0, 2 HR	23 INS, DOPPLER, DR — DEV 0, 2 HR
H	19 IKB ORIENTATION — DEV 0, 2 HR	20 IKB - NAV COURSE SELECT — DEV 0, 1 HR	21 IKB - NAV COURSE SELECT — DEV 2, 2 HR	22 EJECTION SEAT & EGRESS — DEV 0, 2 HR	23 INS, DOPPLER, DR — DEV 0, 4 HR

23	24	25	26	27
FIRE WARNING SYSTEM	ENGINE START APU	TO, LDG. EMERGENCIES	BRIEFING/ DEBRIEFING	TO, LDG. (EMERGENCIES)
DEV 2	DEV 2	DEV 2	DEV B	DEV 3
1 HR	1 HR	2 HR	1 HR	2 HR

25	26	27	28	29
FIRE WARNING SYSTEM	ENGINE START APU	TO, LDG. EMERGENCIES	BRIEFING/ DEBRIEFING	TO, LDG. (EMERGENCIES)
DEV 2	DEV 2	DEV 2	DEV B	DEV 3
1 HR	1 HR	2 HR	1 HR	2 HR

25	26	27	28	29
FIRE WARNING SYSTEM	ENGINE START APU	TO, LDG. EMERGENCIES	BRIEFING/ OEBRIEFING	TO, LDG. (EMERGENCIES)
DEV 2	DEV 2	DEV 2	DEV B	DEV 3
1 HR	1 HR	2 HR	1 HR	2 HR

(C) (C)

25	26	27	28	29
FIRE WARNING SYSTEM	ENGINE START APU	TO, LDG. EMERGENCIES	BRIEFING/ DEBRIEFING	TO, LDG. (EMERGENCIES)
DEV 2	DEV 2	DEV 2	DEV B	DEV 3
1 HR	1 HR	2 HR	1 HR	2 HR

25	26	27	28	29
FIRE WARNING SYSTEM	ENGINE START APU	TO, LDG. EMERGENCIES	BRIEFING/ DEBRIEFING	TO, LDG. (EMERGENCIES)
DEV 2	DEV 2	DEV 2	DEV B	DEV 3
1 HR	1 HR	2 HR	1 HR	2 HR

16	17	18	19	20
INS, DOPPLER DR	PRESENT POSITION CORRECTION	PRESENT POSITION CORRECTION	BRIEFING/ DEBRIEFING	NAVIGATION PRACTICE
DEV 2	DEV 0	DEV 2	DEV B	DEV 3
2 HR	1 HR	1 HR	1 HR	2 HR

24	25	26	27	28
INS, DOPPLER DR	PRESENT POSITION CORRECTION	PRESENT POSITION CORRECTION	BRIEFING/ OEBRIEFING	NAVIGATION PRACTICE
DEV 2	DEV 0	DEV 2	DEV B	DEV 3
2 HR	2 HR	2 HR	1 HR	2 HR

24	25	26	27	28
INS, DOPPLER DR	PRESENT POSITION CORRECTION	PRESENT POSITION CORRECTION	BRIEFING/ DEBRIEFING	NAVIGATION PRACTICE
DEV 2	OEV 0	DEV 2	DEV B	DEV 3
2 HR	2 HR	2 HR	1 HR	2 HR

A	28 FUEL & C.G. MANAGEMENT DEV 1 | 4 HR	29 FUEL & C.G. MANAGEMENT (ALT. PROC.) DEV 2 | 2 HR	30 PERFORMANCE/ MISSION PLANNING DEV 0 | 1 HR	31 AIR REFUELING PROCEDURES DEV 1 | 1 HR	32 BRIEFING DEV B | 1 HR
B	30 FUEL & C.G. MANAGEMENT DEV 1 | 4 HR	31 FUEL & C.G. MANAGEMENT (ALT. PROC.) DEV 2 | 2 HR	32 PERFORMANCE/ MISSION PLANNING DEV 0 | 1 HR	33 AIR REFUELING PROCEDURES DEV 1 | 1 HR	34 BRIEFING DEV B | 1 HR
C	30 FUEL & C.G. MANAGEMENT DEV 1 | 4 HR	31 FUEL & C.G. MANAGEMENT (ALT. PROC.) DEV 2 | 2 HR	32 PERFORMANCE/ MISSION PLANNING DEV 0 | 1 HR	33 AIR REFUELING PROCEDURES DEV 1 | 2 HR	34 BRIEFING DEV B | 1 HR

(C)

D	30 FUEL & C.G. MANAGEMENT DEV 1 | 4 HR	31 FUEL & C.G. MANAGEMENT (ALT. PROC.) DEV 2 | 2 HR	32 PERFORMANCE/ MISSION PLANNING DEV 0 | 1 HR	33 AIR REFUELING PROCEDURES DEV 1 | 1 HR	34 BRIEFING DEV B | 1 HR
E	30 FUEL & C.G. MANAGEMENT DEV 1 | 4 HR	31 FUEL & C.G. MANAGEMENT (ALT. PROC.) DEV 2 | 2 HR	32 PERFORMANCE/ MISSION PLANNING DEV 0 | 1 HR	33 AIR REFUELING PROCEDURES DEV 1 | 2 HR	34 BRIEFING DEV B | 1 HR

F	21 IKB - NAV AUX. NAV. DEV 0 | 1 HR	22 IKB - NAV AUX. NAV. DEV 2 | 2 HR	23 RADAR SET CONTROL DEV 0 | 1 HR	24 FLR BETA SWEEP DEV 0 | 1 HR	25 PERFORMANCE/ MISSION PLANNING (NAV., TFR) DEV 0 | 2 HR
G	29 IKB - NAV AUX. NAV. DEV 0 | 1 HR	30 IKB - NAV AUX. NAV. DEV 2 | 2 HR	31 RADAR SET CONTROL DEV 0 | 2 HR	32 FLR BETA SWEEP DEV 0 | 2 HR	33 PERFORMANCE/ MISSION PLANNING (NAV., TFR) DEV 0 | 2 HR
H	29 IKB - NAV AUX. NAV. DEV 0 | 1 HR	30 IKB - NAV AUX. NAV. DEV 2 | 2 HR	31 RADAR SET CONTROL DEV 0 | 2 HR	32 FLR BETA SWEEP DEV 0 | 2 HR	33 PERFORMANCE/ MISSION PLANNING (NAV., TFR) DEV 0 | 2 HR

33 TO, LOG., AR DEV 3 / 4 HR	34 DEBRIEFING DEV B / 1 HR	35 AFCS (EXCEPT TF & THROTTLE) DEV 1 / 2 HR	36 ELECTRICAL SYSTEM OEV 1 / 1 HR	37 ELECTRICAL SYSTEM (ALT. PROC.) OEV 2 / 2 HR

35 TO, LDG., AR DEV 3 / 4 HR	36 DEBRIEFING DEV B / 1 HR	37 AFCS (EXCEPT TF & THROTTLE) DEV 1 / 2 HR	38 ELECTRICAL SYSTEM DEV 1 / 1 HR	39 ELECTRICAL SYSTEM (ALT. PROC.) OEV 2 / 2 HR

35 TO, LOG., AR DEV 3 / 4 HR	36 DEBRIEFING DEV B / 1 HR	37 AFCS (EXCEPT TF & THROTTLE) DEV 1 / 4 HR	38 ELECTRICAL SYSTEM DEV 1 / 1 HR	39 ELECTRICAL SYSTEM (ALT. PROC.) DEV 2 / 2 HR

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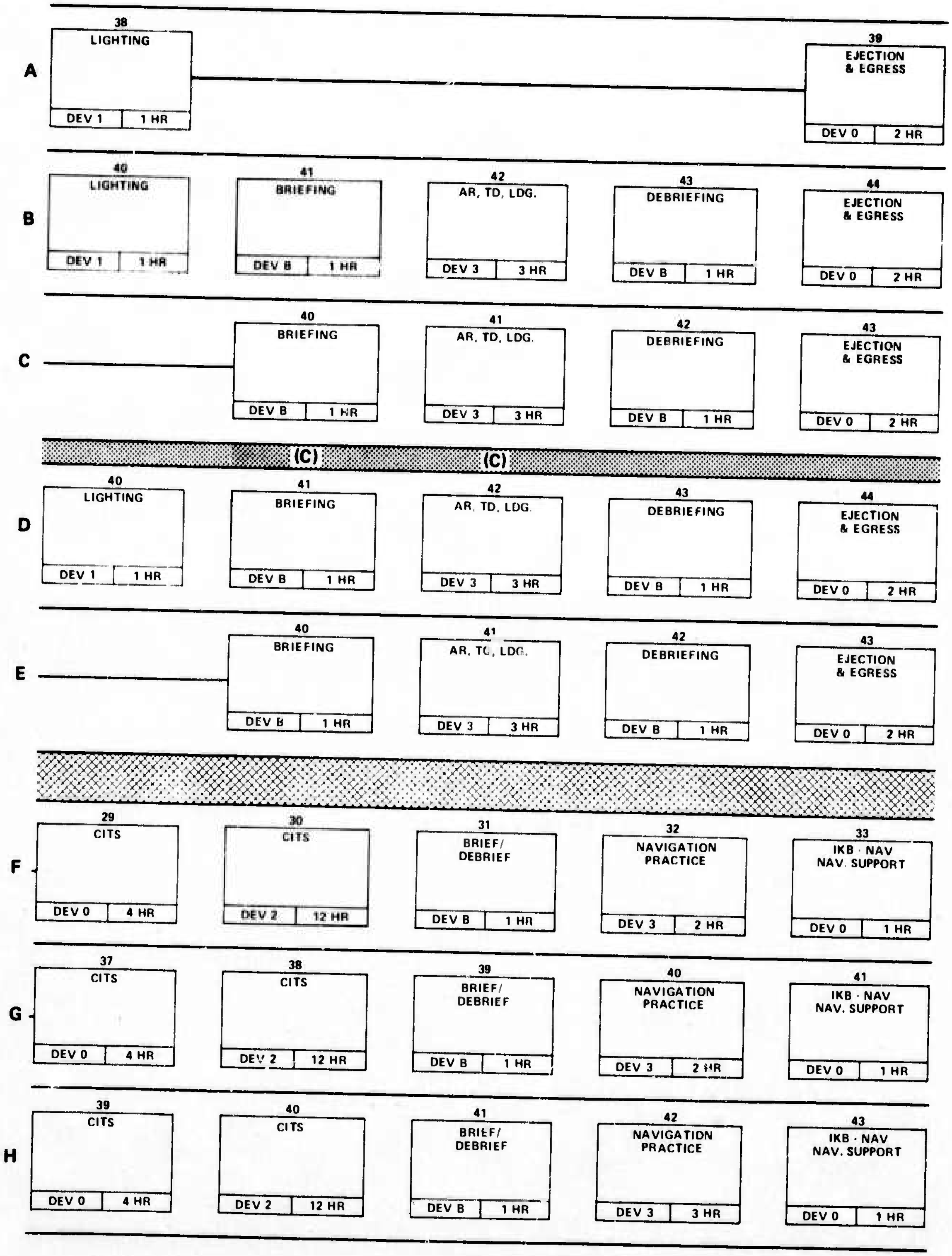
35 TO, LDG., AR DEV 3 / 4 HR	36 DEBRIEFING DEV B / 1 HR	37 AFCS (EXCEPT TF & THROTTLE) DEV 1 / 2 HR	38 ELECTRICAL SYSTEM DEV 1 / 1 HR	39 ELECTRICAL SYSTEM (ALT. PROC.) OEV 2 / 2 HR

35 TO, LDG., AR DEV 3 / 4 HR	36 DEBRIEFING DEV B / 1 HR	37 AFCS (EXCEPT TF & THROTTLE) DEV 1 / 4 HR	38 ELECTRICAL SYSTEM DEV 1 / 1 HR	39 ELECTRICAL SYSTEM (ALT. PROC.) DEV 2 / 2 HR

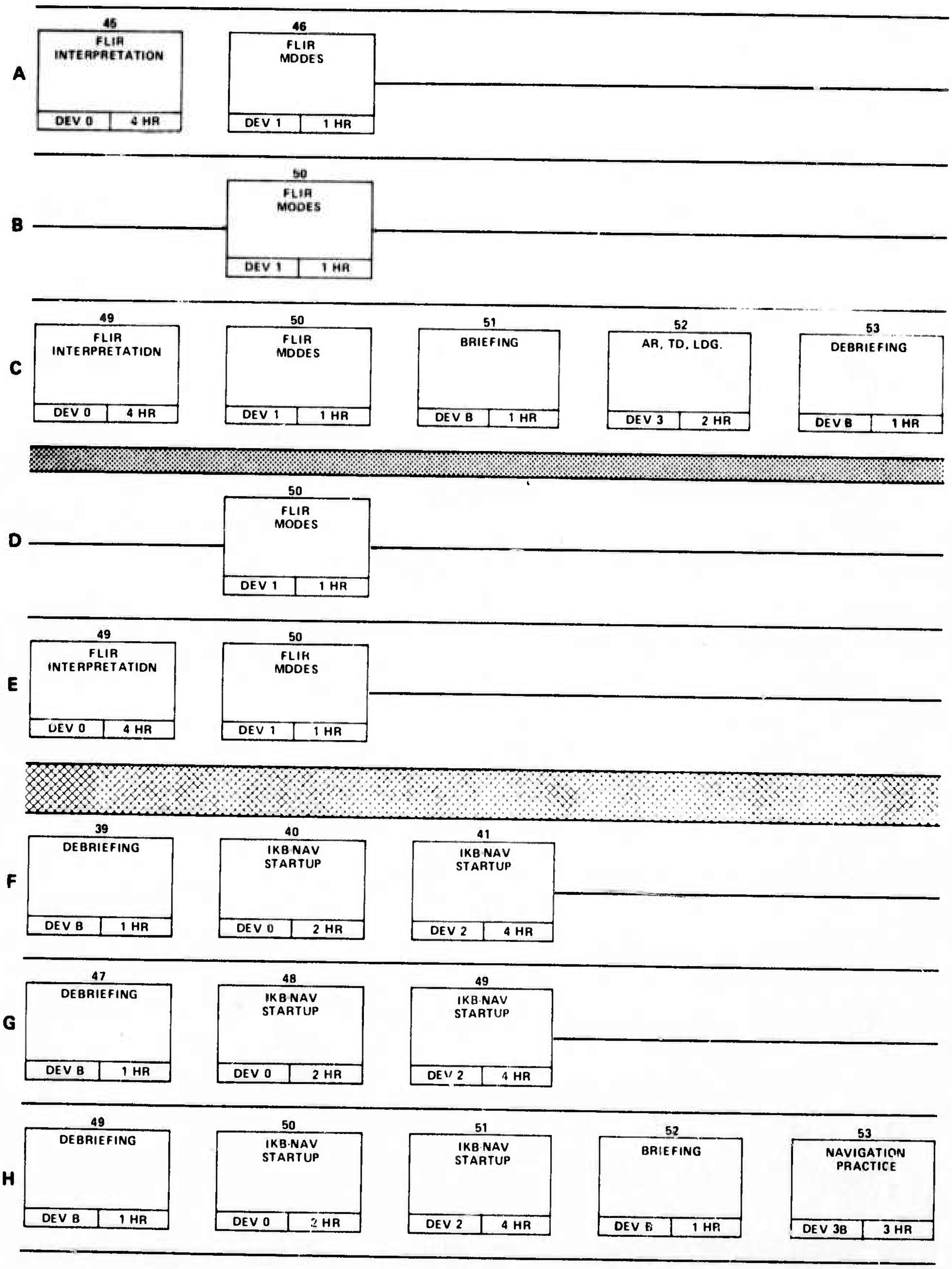
26 BRIEFING/ OEBRIEFING DEV B / 1 HR	27 NAVIGATION PRACTICE DEV 3 / 2 HR	28 ENVIRONMENTAL CONTROL SYSTEM DEV 0 / 1 HR

34 BRIEFING/ OEBRIEFING DEV B / 1 HR	35 NAVIGATION PRACTICE OEV 3 / 3 HR	36 ENVIRONMENTAL CONTROL SYSTEM DEV 0 / 1 HR

34 BRIEFING/ OEBRIEFING DFV B / 1 HR	35 NAVIGATION PRACTICE OEV 3 / 3 HR	36 ENVIRONMENTAL CONTROL SYSTEM DEV 0 / 1 HR	37 BRIEFING/ OEBRIEFING DEV B / 1 HR	38 NAVIGATION PRACTICE DEV 3 / 2 HR


A
38 LIGHTING DEV 1 1 HR
39 EJECTION & EGRESS DEV 0 2 HR
B
40 LIGHTING DEV 1 1 HR
41 BRIEFING DEV B 1 HR
42 AR, TD, LDG. DEV 3 3 HR
43 DEBRIEFING DEV B 1 HR
44 EJECTION & EGRESS DEV 0 2 HR
C
40 BRIEFING DEV B 1 HR
41 AR, TD, LDG. DEV 3 3 HR
42 DEBRIEFING DEV B 1 HR
43 EJECTION & EGRESS DEV 0 2 HR
(C)
(C)
D
40 LIGHTING DEV 1 1 HR
41 BRIEFING DEV B 1 HR
42 AR, TD, LDG. DEV 3 3 HR
43 DEBRIEFING DEV B 1 HR
44 EJECTION & EGRESS DEV 0 2 HR
E
40 BRIEFING DEV B 1 HR
41 AR, TD, LDG. DEV 3 3 HR
42 DEBRIEFING DEV B 1 HR
43 EJECTION & EGRESS DEV 0 2 HR
F
29 CITS DEV 0 4 HR
30 CITS DEV 2 12 HR
31 BRIEF/ DEBRIEF DEV B 1 HR
32 NAVIGATION PRACTICE DEV 3 2 HR
33 IKB - NAV NAV. SUPPORT DEV 0 1 HR
G
37 CITS DEV 0 4 HR
38 CITS DEV 2 12 HR
39 BRIEF/ DEBRIEF DEV B 1 HR
40 NAVIGATION PRACTICE DEV 3 2 HR
41 IKB - NAV NAV. SUPPORT DEV 0 1 HR
H
39 CITS DEV 0 4 HR
40 CITS DEV 2 12 HR
41 BRIEF/ DEBRIEF DEV B 1 HR
42 NAVIGATION PRACTICE DEV 3 3 HR
43 IKB - NAV NAV. SUPPORT DEV 0 1 HR

40 EMERGENCY PROCEDURES DEV 2 | 2 HR	41 BRIEFING DEV B | 1 HR	42 AFCS, TO, LDG., AR (EMERGENCIES) DEV 3 | 3 HR	43 DEBRIEFING DEV B | 1 HR	44 EMERGENCY PROCEDURES DEV 2 | 2 HR
45 EMERGENCY PROCEDURES DEV 2 | 2HR	46 BRIEFING DEV B | 1 HR	47 AFCS, TO, LDG., AR (EMERGENCIES) DEV 3 | 3 HR	48 DEBRIEFING DEV B | 1 HR	49 EMERGENCY PROCEDURES DEV 2 | 2 HR
44 EMERGENCY PROCEDURES DEV 2 | 2 HR	45 BRIEFING DEV B | 1 HR	46 AFCS, TO, LDG., AR (EMERGENCIES) DEV 3 | 3 HR	47 DEBRIEFING DEV B | 1 HR	48 EMERGENCY PROCEDURES DEV 2 | 2 HR
(C)	(C)	(C)	(C)	(C)
45 EMERGENCY PROCEDURES DEV 2 | 2 HR	46 BRIEFING DEV B | 1 HR	47 AFCS, TO, LDG., AR (EMERGENCIES) DEV 3 | 3 HR	48 DEBRIEFING DEV B | 1 HR	49 EMERGENCY PROCEDURES DEV 2 | 2 HR
44 EMERGENCY PROCEDURES DEV 2 | 2 HR	45 BRIEFING DEV B | 1 HR	46 AFCS, TO, LDG., AR (EMERGENCIES) DEV 3 | 3 HR	47 DEBRIEFING DEV B | 1 HR	48 EMERGENCY PROCEDURES DEV 2 | 2 HR
34 IKB · NAV NAV. SUPPORT DEV 2 | 1 HR	35 FLIR INTRODUCTION & INTERPRETATION DEV 0 | 6 HR	36 EVS CONTROLS DEV 2 | 2 HR	37 BRIEFING DEV B | 1 HR	38 NAVIGATION PRACTICE DEV 3 | 2 HR
42 IKB · NAV NAV. SUPPORT DEV 2 | 1 HR	43 FLIR INTRODUCTION & INTERPRETATION DEV 0 | 2 HR	44 EVS CONTROLS DEV 2 | 1 HR	45 BRIEFING DEV B | 1 HR	46 NAVIGATION PRACTICE DEV 3 | 3 HR
44 IKB · NAV NAV. SUPPORT DEV 2 | 1 HR	45 FLIR INTRODUCTION & INTERPRETATION DEV 0 | 6 HR	46 EVS CONTROLS DEV 2 | 2 HR	47 BRIEFING DEV B | 1 HR	48 NAVIGATION PRACTICE DEV 3 | 3 HR


A
45
FLIR INTERPRETATION
DEV 0
4 HR
46
FLIR MODES
DEV 1
1 HR
B
50
FLIR MODES
DEV 1
1 HR
C
49
FLIR INTERPRETATION
DEV 0
4 HR
50
FLIR MODES
DEV 1
1 HR
51
BRIEFING
DEV B
1 HR
52
AR, TD, LDG.
DEV 3
2 HR
53
DEBRIEFING
DEV B
1 HR
D
50
FLIR MODES
DEV 1
1 HR
E
49
FLIR INTERPRETATION
DEV 0
4 HR
50
FLIR MODES
DEV 1
1 HR
F
39
DEBRIEFING
DEV B
1 HR
40
IKB NAV STARTUP
DEV 0
2 HR
41
IKB NAV STARTUP
DEV 2
4 HR
G
47
DEBRIEFING
DEV B
1 HR
48
IKB NAV STARTUP
DEV 0
2 HR
49
IKB NAV STARTUP
DEV 2
4 HR
H
49
DEBRIEFING
DEV B
1 HR
50
IKB NAV STARTUP
DEV 0
2 HR
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DEV 2
4 HR
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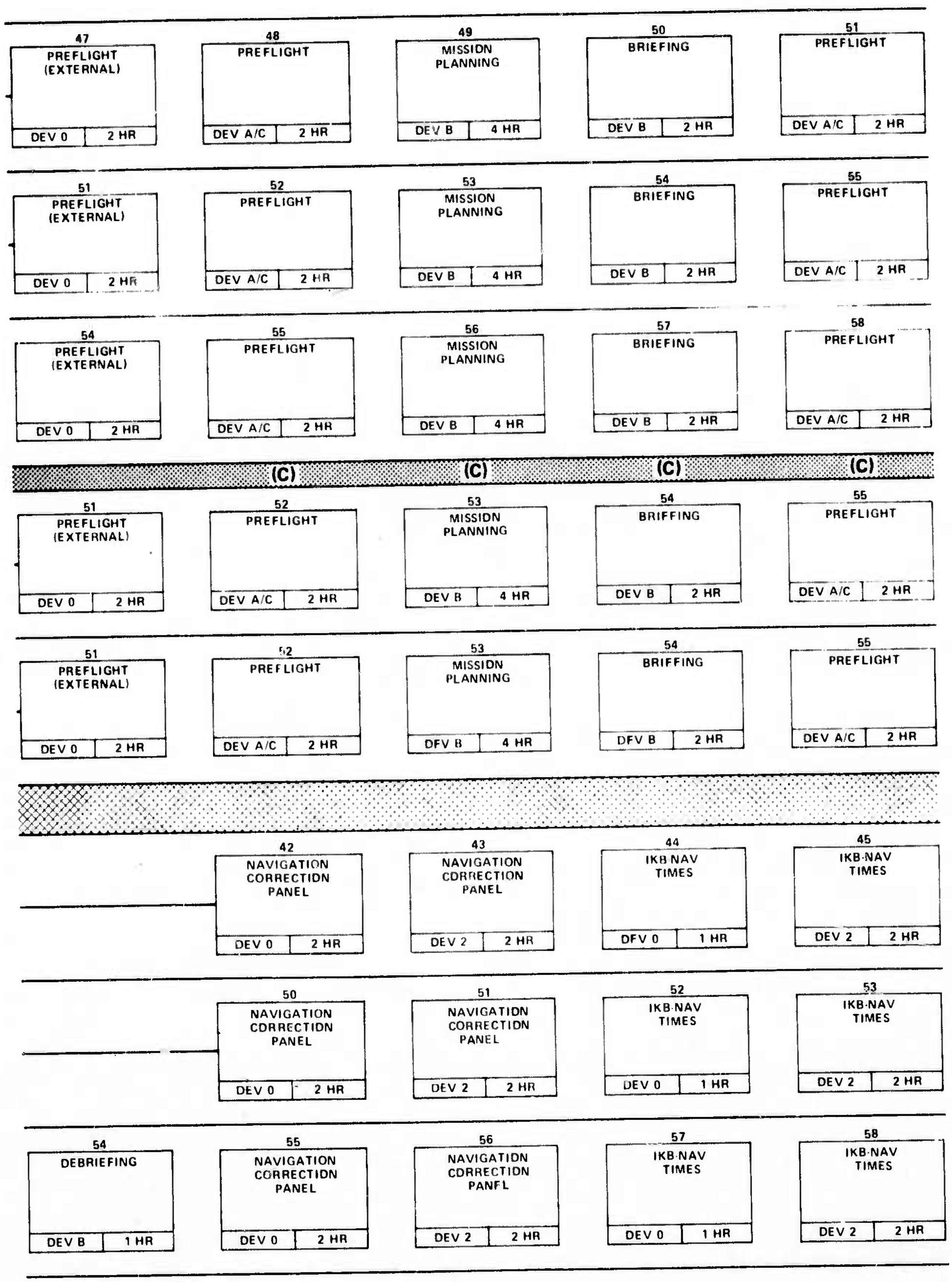
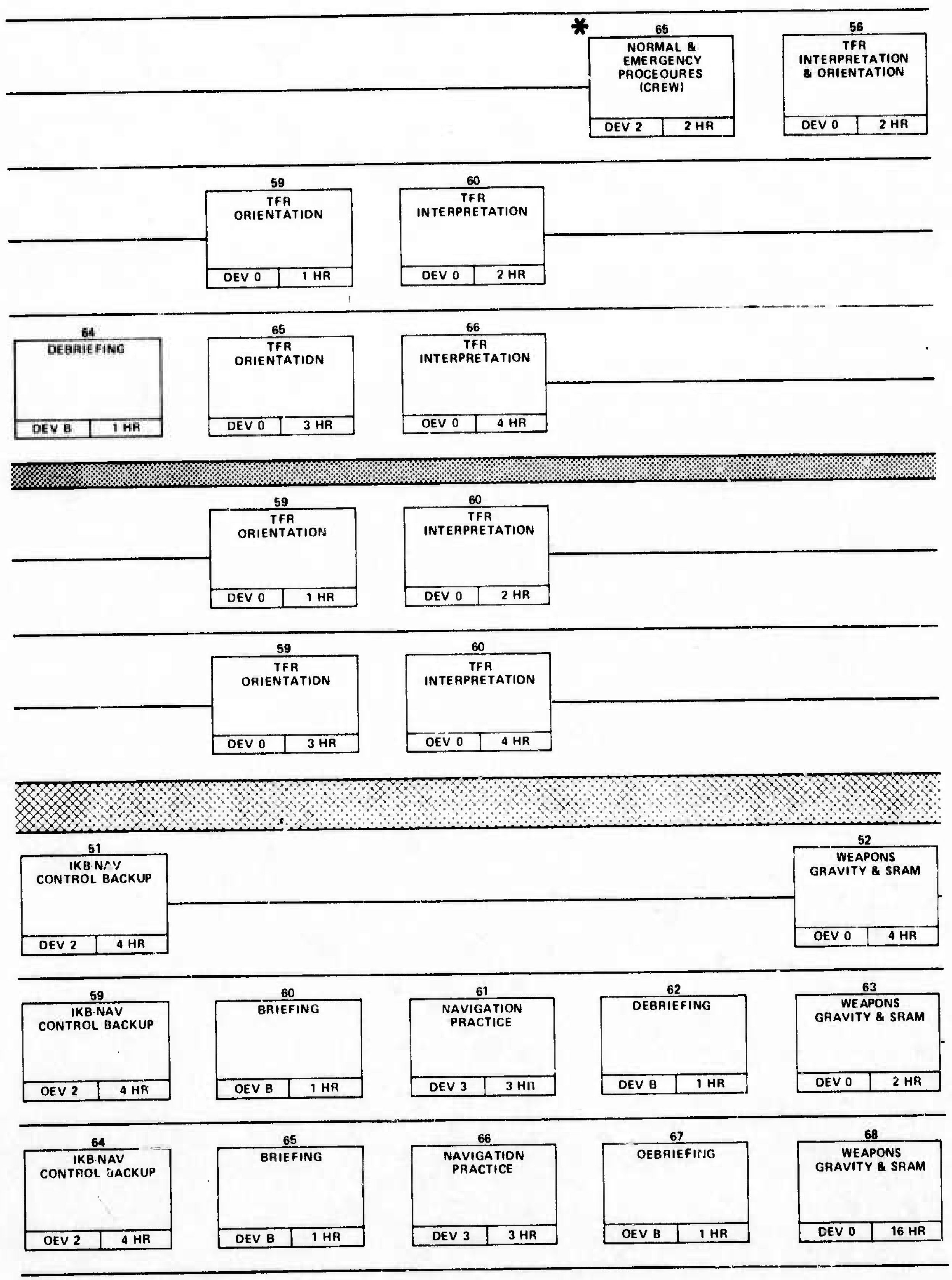
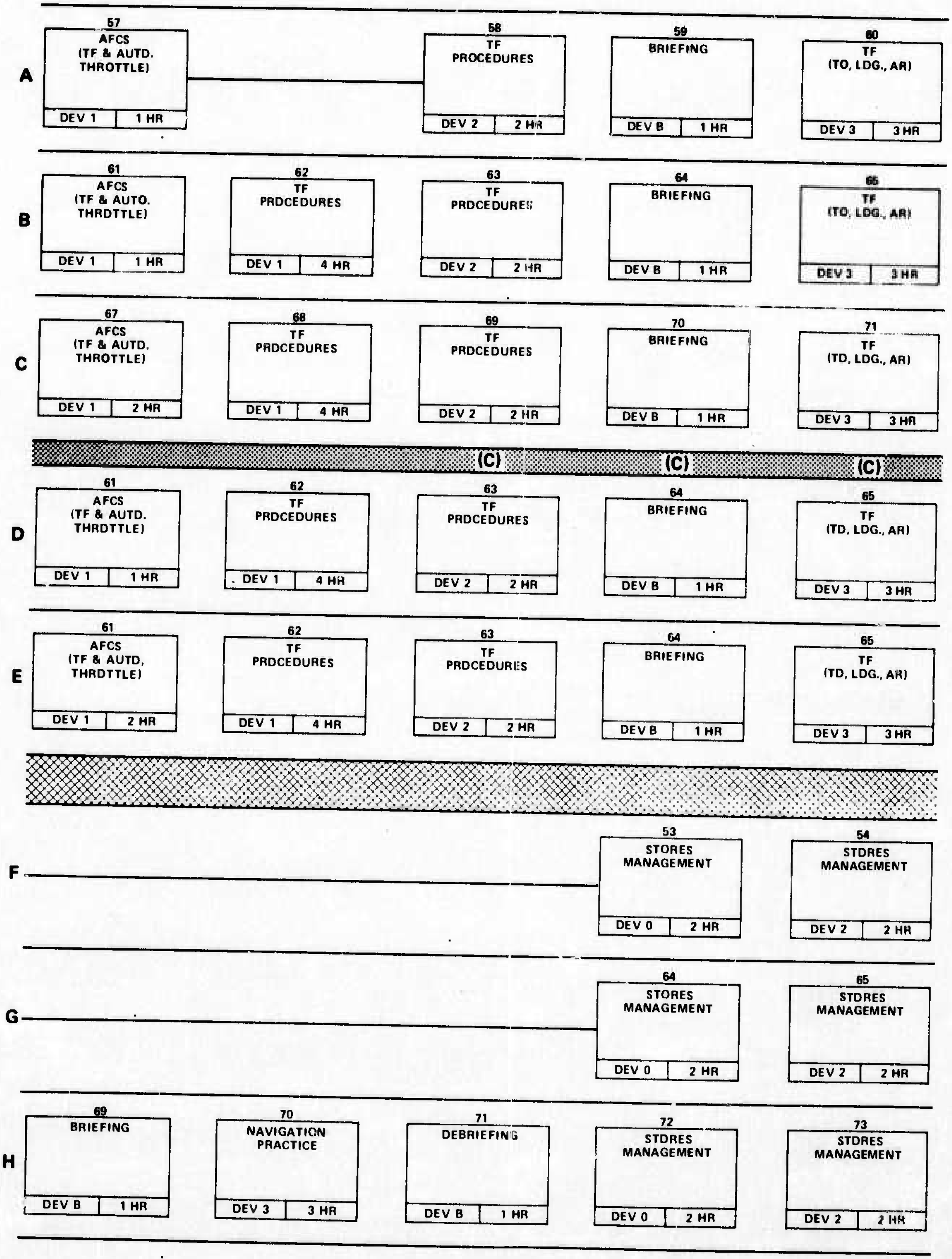
BRIEFING
DEV B
1 HR
53
NAVIGATION PRACTICE
DEV 3B
3 HR



47 PREFLIGHT (EXTERNAL) DEV 0 2 HR
48 PREFLIGHT DEV A/C 2 HR
49 MISSION PLANNING DEV B 4 HR
50 BRIEFING DEV B 2 HR
51 PREFLIGHT DEV A/C 2 HR
51 PREFLIGHT (EXTERNAL) DEV 0 2 HR
52 PREFLIGHT DEV A/C 2 HR
53 MISSION PLANNING DEV B 4 HR
54 BRIEFING DEV B 2 HR
55 PREFLIGHT DEV A/C 2 HR
54 PREFLIGHT (EXTERNAL) DEV 0 2 HR
55 PREFLIGHT DEV A/C 2 HR
56 MISSION PLANNING DEV B 4 HR
57 BRIEFING DEV B 2 HR
58 PREFLIGHT DEV A/C 2 HR
(C)
(C)
(C)
(C)
51 PREFLIGHT (EXTERNAL) DEV 0 2 HR
52 PREFLIGHT DEV A/C 2 HR
53 MISSION PLANNING DEV B 4 HR
54 BRIFFING DEV B 2 HR
55 PREFLIGHT DEV A/C 2 HR
51 PREFLIGHT (EXTERNAL) DEV 0 2 HR
52 PREFLIGHT DEV A/C 2 HR
53 MISSION PLANNING DEV B 4 HR
54 BRIFFING DEV B 2 HR
55 PREFLIGHT DEV A/C 2 HR
42 NAVIGATION CORRECTION PANEL DEV 0 2 HR
43 NAVIGATION CORRECTION PANEL DEV 2 2 HR
44 IKB NAV TIMES DEV 0 1 HR
45 IKB NAV TIMES DEV 2 2 HR
50 NAVIGATION CORRECTION PANEL DEV 0 2 HR
51 NAVIGATION CORRECTION PANEL DEV 2 2 HR
52 IKB NAV TIMES DEV 0 1 HR
53 IKB NAV TIMES DEV 2 2 HR
54 DEBRIEFING DEV B 1 HR
55 NAVIGATION CORRECTION PANEL DEV 0 2 HR
56 NAVIGATION CORRECTION PANEL DEV 2 2 HR
57 IKB NAV TIMES DEV 0 1 HR
58 IKB NAV TIMES DEV 2 2 HR

A	52 TO, LDG., AR — DEV A/C, 4 HR	53 DEBRIEFING — DEV B, 2 HR	54 PERFORMANCE/ MISSION PLANNING (NAV., TF) — DEV 0, 2 HR		
B	56 TO, LDG., AR — DEV A/C, 4 HR	57 DEBRIEFING — DEV B, 2 HR	58 PERFORMANCE/ MISSION PLANNING (NAV., TF) — DEV 0, 2 HR		
C	59 TO, LDG., AR — DEV A/C, 4 HR	60 DEBRIEFING — DEV B, 2 HR	61 PERFORMANCE/ MISSION PLANNING (NAV., TF) — DEV 0, 2 HR	62 BRIEFING — DEV B, 1 HR	63 PROBLEMS FROM A/C MISSION — DEV 3, 3 HR
	(C)	(C)			
D	56 TO, LDG., AR — DEV A/C, 4 HR	57 DEBRIEFING — DEV B, 2 HR	58 PERFORMANCE/ MISSION PLANNING (NAV., TF) — DEV 0, 2 HR		
E	56 TO, LDG., AR — DEV A/C, 4 HR	57 DEBRIEFING — DEV B, 2 HR	58 PERFORMANCE/ MISSION PLANNING (NAV., TF) — DEV 0, 2 HR		
F	46 FLIR-FLR CORRELATION — DEV 0, 1 HR	47 BRIEFING — DEV B, 1 HR	48 NAVIGATION PRACTICE (PIP-IP-TARGET-FLIR-FLR) — DEV 3, 4 HR	49 DEBRIEFING — DEV B, 1 HR	50 IKB-NAV CONTROL BACKUP — DEV 0, 1 HR
G	54 FLIR-FLR CORRELATION — DEV 0, 1 HR	55 BRIEFING — DEV B, 1 HR	56 NAVIGATION PRACTICE (PIP-IP-TARGET-FLIR-FLR) — DEV 3, 4 HR	57 DEBRIEFING — DEV B, 1 HR	58 IKB-NAV CONTROL BACKUP — DEV 0, 1 HR
H	59 FLIR-FLR CORRELATION — DEV 0, 2 HR	60 BRIEFING — DEV B, 1 HR	61 NAVIGATION PRACTICE (PIP-IP-TARGET-FLIR-FLR) — DEV 3, 4 HR	62 DEBRIEFING — DEV B, 1 HR	63 IKB-NAV CONTROL BACKUP — DEV 0, 1 HR


*
55
NORMAL & EMERGENCY PROCEDURES (CREW)
DEV 2
2 HR
56
TFR INTERPRETATION & ORIENTATION
DEV 0
2 HR
59
TFR ORIENTATION
DEV 0
1 HR
60
TFR INTERPRETATION
DEV 0
2 HR
64
DEBRIEFING
DEV B
1 HR
65
TFR ORIENTATION
DEV 0
3 HR
66
TFR INTERPRETATION
DEV 0
4 HR
59
TFR ORIENTATION
DEV 0
1 HR
60
TFR INTERPRETATION
DEV 0
2 HR
59
TFR ORIENTATION
DEV 0
3 HR
60
TFR INTERPRETATION
DEV 0
4 HR
51
IKB-NAV CONTROL BACKUP
DEV 2
4 HR
52
WEAPONS GRAVITY & SRAM
DEV 0
4 HR
59
IKB-NAV CONTROL BACKUP
DEV 2
4 HR
60
BRIEFING
DEV B
1 HR
61
NAVIGATION PRACTICE
DEV 3
3 HR
62
DEBRIEFING
DEV B
1 HR
63
WEAPONS GRAVITY & SRAM
DEV 0
2 HR
64
IKB-NAV CONTROL BACKUP
DEV 2
4 HR
65
BRIEFING
DEV B
1 HR
66
NAVIGATION PRACTICE
DEV 3
3 HR
67
DEBRIEFING
DEV B
1 HR
68
WEAPONS GRAVITY & SRAM
DEV 0
16 HR


A
57 AFCS (TF & AUTD. THROTTLE) DEV 1 1 HR
58 TF PROCEDURES DEV 2 2 HR
59 BRIEFING DEV B 1 HR
60 TF (TO, LDG., AR) DEV 3 3 HR
B
61 AFCS (TF & AUTO. THRDTTLE) DEV 1 1 HR
62 TF PRDCEDURES DEV 1 4 HR
63 TF PRDCEDURES DEV 2 2 HR
64 BRIEFING DEV B 1 HR
65 TF (TO, LDG., AR) DEV 3 3 HR
C
67 AFCS (TF & AUTD. THROTTLE) DEV 1 2 HR
68 TF PRDCEDURES DEV 1 4 HR
69 TF PRDCEDURES DEV 2 2 HR
70 BRIEFING DEV B 1 HR
71 TF (TD, LDG., AR) DEV 3 3 HR
(C)
(C)
(C)
D
61 AFCS (TF & AUTD. THRDTTLE) DEV 1 1 HR
62 TF PRDCEDURES DEV 1 4 HR
63 TF PRDCEDURES DEV 2 2 HR
64 BRIEFING DEV B 1 HR
65 TF (TD, LDG., AR) DEV 3 3 HR
E
61 AFCS (TF & AUTD, THRDTTLE) DEV 1 2 HR
62 TF PRDCEDURES DEV 1 4 HR
63 TF PRDCEDURES DEV 2 2 HR
64 BRIEFING DEV B 1 HR
65 TF (TD, LDG., AR) DEV 3 3 HR
F
53 STDRES MANAGEMENT DEV 0 2 HR
54 STDRES MANAGEMENT DEV 2 2 HR
G
64 STORES MANAGEMENT DEV 0 2 HR
65 STDRES MANAGEMENT DEV 2 2 HR
H
69 BRIEFING DEV B 1 HR
70 NAVIGATICN PRACTICE DEV 3 3 HR
71 DEBRIEFING DEV B 1 HR
72 STDRES MANAGEMENT DEV 0 2 HR
73 STDRES MANAGEMENT DEV 2 2 HR

61 DEBRIEFING	62 INSTRUMENT SCHOOL	63 BRIEFING	64 INSTRUMENT CHECK
DEV B — 1 HR	DEV 0 — 8 HR	DEV B — 2 HR	DEV 3 — 3 HR

66 DEBRIEFING	* 67 NORMAL & EMERGENCY PROCEDURES (CREW)	68 INSTRUMENT SCHOOL	69 BRIEFING	70 INSTRUMENT CHECK
DEV B — 1 HR	DEV 2 — 2 HR	DEV 0 — 8 HR	DEV B — 2 HR	DEV 3 — 3 HR

72 DEBRIEFING	73 INSTRUMENT SCHOOL	74 BRIEFING	75 INSTRUMENT CHECK
DEV B — 1 HR	DEV 0 — 8 HR	DEV B — 2 HR	DEV 3 — 3 HR

(C)

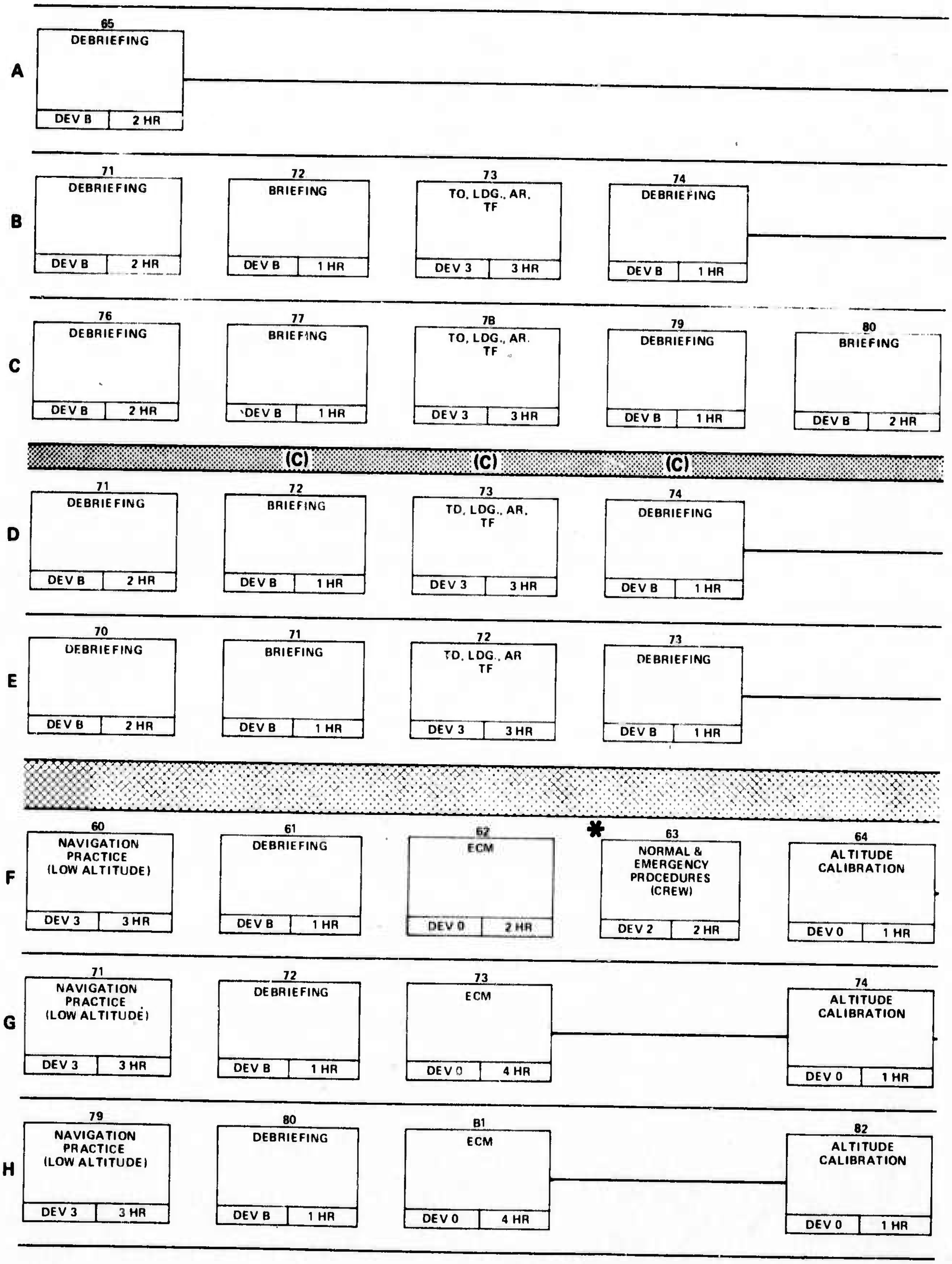
66 DEBRIEFING	* 67 NORMAL & EMERGENCY PROCEDURES (CREW)	68 INSTRUMENT SCHOOL	69 BRIEFING	70 INSTRUMENT CHECK
DEV B — 1 HR	DEV 2 — 2 HR	DEV 0 — 8 HR	DEV B — 2 HR	DEV 3 — 3 HR

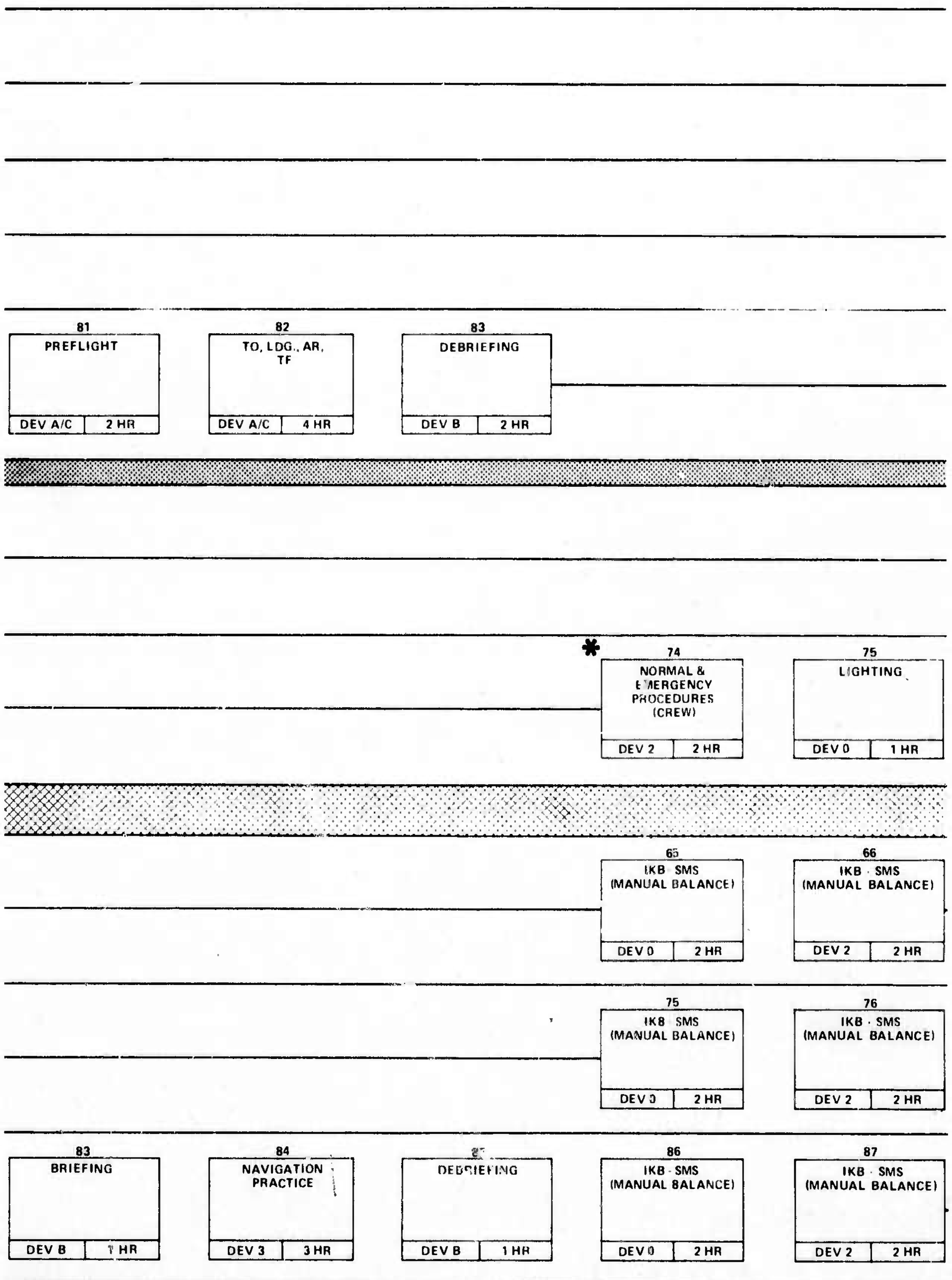
66 DEBRIEFING	67 INSTRUMENT SCHOOL	68 BRIEFING	69 INSTRUMENT CHECK
DEV B — 1 HR	DEV 0 — 8 HR	DEV B — 2 HR	DEV 3 — 3 HR

55 SMS FORMATS (EXCEPT SUMMARY, NUC., & SELECT STATION STATUS)	56 SMS FORMATS (EXCEPT SUMMARY, NUC., & SELECT STATION STATUS)	57 IKB · SMS	58 IKB · SMS	59 BRIEFING
DEV 0 — 2 HR	DEV 2 — 2 HR	DEV 0 — 2 HR	DEV 2 — 2 HR	DEV B — 1 HR

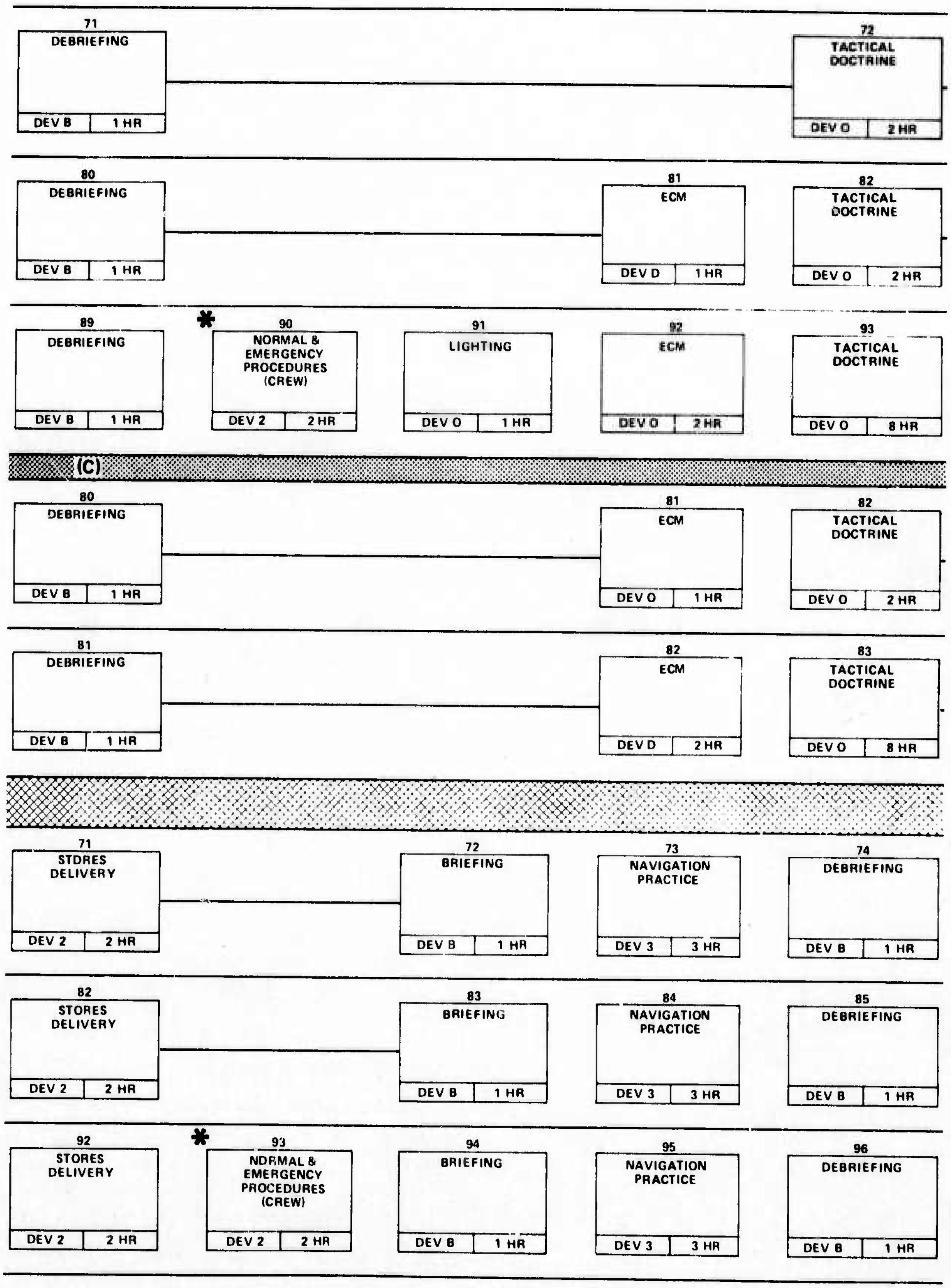
66 SMS FORMATS (EXCEPT SUMMARY, NUC., & SELECT STATION STATUS)	67 SMS FORMATS (EXCEPT SUMMARY, NUC., & SELECT STATION STATUS)	68 IKB · SMS	69 IKB·SMS	70 BRIEFING
DEV 0 — 2 HR	DEV 2 — 2 HR	DEV 0 — 2 HR	DEV 2 — 2 HR	DEV B — 1 HR

74 SMS FORMATS (EXCEPT SUMMARY, NUC., & SELECT STATION STATUS)	75 SMS FORMATS (EXCEPT SUMMARY, NUC., & SELECT STATION STATUS)	76 IKB SMS	77 IKB · SMS	78 BRIEFING
DEV 0 — 2 HR	DEV 2 — 2 HR	DEV 0 — 2 HR	DEV 2 — 2 HR	DEV B — 1 HR


A
65 DEBRIEFING DEV B 2 HR
B
71 DEBRIEFING DEV B 2 HR
72 BRIEFING DEV B 1 HR
73 TO, LDG., AR, TF DEV 3 3 HR
74 DEBRIEFING DEV B 1 HR
C
76 DEBRIEFING DEV B 2 HR
77 BRIEFING DEV B 1 HR
78 TO, LDG., AR, TF DEV 3 3 HR
79 DEBRIEFING DEV B 1 HR
80 BRIEFING DEV B 2 HR
(C) (C) (C)
D
71 DEBRIEFING DEV B 2 HR
72 BRIEFING DEV B 1 HR
73 TD, LDG., AR, TF DEV 3 3 HR
74 DEBRIEFING DEV B 1 HR
E
70 DEBRIEFING DEV B 2 HR
71 BRIEFING DEV B 1 HR
72 TD, LDG., AR TF DEV 3 3 HR
73 DEBRIEFING DEV B 1 HR
F
60 NAVIGATION PRACTICE (LOW ALTITUDE) DEV 3 3 HR
61 DEBRIEFING DEV B 1 HR
62 ECM DEV 0 2 HR
* 63 NORMAL & EMERGENCY PROCEDURES (CREW) DEV 2 2 HR
64 ALTITUDE CALIBRATION DEV 0 1 HR
G
71 NAVIGATION PRACTICE (LOW ALTITUDE) DEV 3 3 HR
72 DEBRIEFING DEV B 1 HR
73 ECM DEV 0 4 HR
74 ALTITUDE CALIBRATION DEV 0 1 HR
H
79 NAVIGATION PRACTICE (LOW ALTITUDE) DEV 3 3 HR
80 DEBRIEFING DEV B 1 HR
81 ECM DEV 0 4 HR
82 ALTITUDE CALIBRATION DEV 0 1 HR

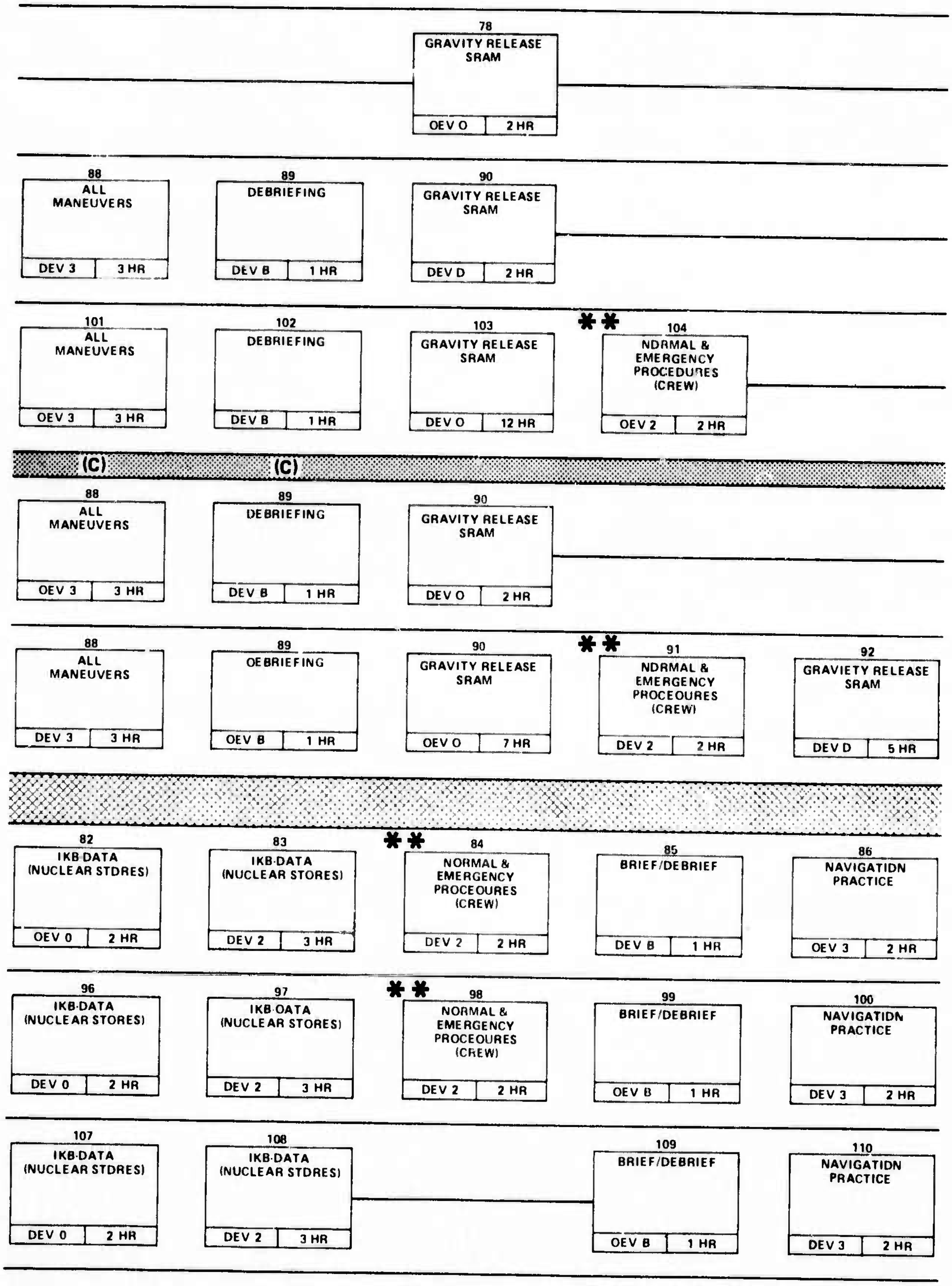

81
PREFLIGHT
DEV A/C
2 HR
82
TO, LDG., AR, TF
DEV A/C
4 HR
83
DEBRIEFING
DEV B
2 HR
74
NORMAL & EMERGENCY PROCEDURES (CREW)
DEV 2
2 HR
75
LIGHTING
DEV 0
1 HR
65
IKB SMS (MANUAL BALANCE)
DEV 0
2 HR
66
IKB · SMS (MANUAL BALANCE)
DEV 2
2 HR
75
IKB SMS (MANUAL BALANCE)
2 HR
76
IKB · SMS (MANUAL BALANCE)
DEV 2
2 HR
83
BRIEFING
DEV B
1 HR
84
NAVIGATION PRACTICE
DEV 3
3 HR
DEBRIEFING
DEV B
1 HR
86
IKB · SMS (MANUAL BALANCE)
DEV 0
2 HR
87
IKB · SMS (MANUAL BALANCE)
DEV 2
2 HR

A	66 ENVIRONMENTAL CONTROL SYSTEM — DEV 1, 2 HR	67 ENVIRONMENT CONTROL SYSTEM (ALT. PROC.) — DEV 2, 2 HR	68 MANUAL TERRAIN FOLLOWING — DEV 0, 1 HR	69 BRIEFING — DEV B, 1 HR	70 TF (ATF, MTF) + ALL MANEUVERS — DEV 3, 3 HR
B	75 ENVIRONMENTAL CONTROL SYSTEM — DEV 1, 2 HR	76 ENVIRONMENT CONTROL SYSTEM (ALT. PROC.) — DEV 2, 2 HR	77 MANUAL TERRAIN FOLLOWING — DEV 0, 1 HR	78 BRIEFING — DEV B, 1 HR	79 TF (ATF, MTF) + ALL MANEUVERS — DEV 3, 3 HR
C	84 ENVIRONMENTAL CONTROL SYSTEM — DEV 1, 2 HR	85 ENVIRONMENT CONTROL SYSTEM (ALT. PROC.) — DEV 2, 2 HR	86 MANUAL TERRAIN FOLLOWING — DEV 0, 1 HR	87 BRIEFING — DEV B, 1 HR	88 TF (AFT, MTF) + ALL MANEUVERS — DEV 3, 3 HR
		(C)		(C)	(C)
D	75 ENVIRONMENTAL CONTROL SYSTEM — DEV 1, 2 HR	76 ENVIRONMENT CONTROL SYSTEM (ALT. PROC.) — DEV 2, 2 HR	77 MANUAL TERRAIN FOLLOWING — DEV 0, 1 HR	78 BRIEFING — DEV B, 1 HR	79 TF (ATF, MTF) + ALL MANEUVERS — DEV 3, 3 HR
E	76 ENVIRONMENTAL CONTROL SYSTEM — DEV 1, 2 HR	77 ENVIRONMENT CONTROL SYSTEM (ALT. PROC.) — DEV 2, 2 HR	78 MANUAL TERRAIN FOLLOWING — DEV 0, 1 HR	79 BRIEFING — DEV B, 1 HR	80 TF (AFT, MTF) + ALL MANEUVERS — DEV 3, 3 HR
F		67 SMS FORMATS (SUMMARY, NUC., & SELECT STATION STATUS) — DEV 0, 2 HR	68 SMS FORMATS (SUMMARY, NUC., & SELECT STATION STATUS) — DEV 2, 2 HR	69 SMS (CONV., NUC., ETT.) — DEV 0, 1 HR	70 STORES DELIVERY — DEV 0, 2 HR
G	77 NORMAL & EMERGENCY PROCEDURES (CREW) — DEV 2, 2 HR	78 SMS FORMATS (SUMMARY, NUC., & SELECT STATION STATUS) — DEV 0, 2 HR	79 SMS FORMATS (SUMMARY, NUC., & SELECT STATION STATUS) — DEV 2, 2 HR	80 SMS (CONV., NUC., ETT.) — DEV 0, 1 HR	81 STORES DELIVERY — DEV 0, 2 HR
H		88 SMS FORMATS (SUMMARY, NUC., & SELECT STATION STATUS) — DEV 0, 2 HR	89 SMS FORMATS (SUMMARY, NUC., & SELECT STATION STATUS) — DEV 2, 2 HR	90 SMS (CONV., NUC., ETT.) — DEV 0, 1 HR	91 STORES DELIVERY — DEV 0, 2 HR


71
DEBRIEFING
DEV B
1 HR
72
TACTICAL DOCTRINE
DEV O
2 HR
80
DEBRIEFING
DEV B
1 HR
81
ECM
DEV D
1 HR
82
TACTICAL DOCTRINE
DEV O
2 HR
89
DEBRIEFING
DEV B
1 HR
*
90
NORMAL & EMERGENCY PROCEDURES (CREW)
DEV 2
2 HR
91
LIGHTING
DEV O
1 HR
92
ECM
DEV O
2 HR
93
TACTICAL DOCTRINE
DEV O
8 HR
(C)
80
DEBRIEFING
DEV B
1 HR
81
ECM
DEV O
1 HR
82
TACTICAL DOCTRINE
DEV O
2 HR
81
DEBRIEFING
DEV B
1 HR
82
ECM
DEV D
2 HR
83
TACTICAL DOCTRINE
DEV O
8 HR
71
STORES DELIVERY
DEV 2
2 HR
72
BRIEFING
DEV B
1 HR
73
NAVIGATION PRACTICE
DEV 3
3 HR
74
DEBRIEFING
DEV B
1 HR
82
STORES DELIVERY
DEV 2
2 HR
83
BRIEFING
DEV B
1 HR
84
NAVIGATION PRACTICE
DEV 3
3 HR
85
DEBRIEFING
DEV B
1 HR
92
STORES DELIVERY
DEV 2
2 HR
*
93
NORMAL & EMERGENCY PROCEDURES (CREW)
DEV 2
2 HR
94
BRIEFING
DEV B
1 HR
95
NAVIGATION PRACTICE
DEV 3
3 HR
96
DEBRIEFING
DEV B
1 HR

A				73 PERFORMANCE/ MISSION PLANNING (NAV., SUPERSONIC) — OEV 0 — 2 HR	** 74 NORMAL & EMERGENCY PROCEDURES (CREW) — DEV 2 — 2 HR
B				83 PERFORMANCE/ MISSION PLANNING (NAV., SUPERSONIC) — OEV 0 — 2 HR	
C	94 BRIEFING — DEV B — 1 HR	95 ALL MANEUVERS — DEV 3 — 3 HR	96 DEBRIEFING — DEV B — 1 HR	97 PERFORMANCE/ MISSION PLANNING (NAV., SUPERSONIC) — DEV 0 — 2 HR	
D				83 PERFORMANCE/ MISSION PLANNING (NAV., SUPERSONIC) — DEV 0 — 2 HR	
E				84 PERFORMANCE/ MISSION PLANNING (NAV., SUPERSONIC) — DEV 0 — 2 HR	
F	75 TACTICAL OOCTRINE — DEV 0 — 2 HR	76 IKB-SMS (CONTROL BACKUP) — DEV 0 — 2 HR	77 IKB-SMS (CONTROL BACKUP) — DEV 2 — 4 HR	78 IKB-ACU — OEV 0 — 2 HR	79 IKB-ACU — DEV 2 — 2 HR
G	86 TACTICAL DOCTRINE — OEV 0 — 2 HR	87 IKB · SMS (CONTROL BACKUP) — OEV 0 — 2 HR	88 IKB · SMS (CONTROL BACKUP) — DEV 2 — 4 HR	89 IKB-ACU — DEV 0 — 2 HR	90 IKB-ACU — OEV 2 — 2 HR
H	97 TACTICAL OOCTRINE — OEV 0 — 6 HR	98 IKB · SMS (CONTROL BACKUP) — DEV 0 — 2 HR	99 IKB · SMS (CONTROL BACKUP) — DEV 2 — 4 HR	100 IKB-ACU — OEV 0 — 2 HR	101 IKB-ACU — OEV 2 — 2 HR

A	75 ECM (DEV 0, 1 HR)	76 SUPERSONIC FLIGHT (DEV D, 2 HR)	77 EMERGENCY PROCEDURES (DEV 2, 2 HR)		
B		84 SUPERSONIC FLIGHT (DEV D, 2 HR)	85 EMERGENCY PROCEDURES (DEV 2, 2 HR)	** 86 NORMAL & EMERGENCY PROCEDURES (CREW) (DEV 2, 2 HR)	87 BRIEFING (DEV B, 1 HR)
C		98 SUPERSONIC FLIGHT (DEV D, 2 HR)	99 EMERGENCY PROCEDURES (DEV 2, 2 HR)		100 BRIEFING (DEV B, 1 HR)
			(C)		(C)
D		84 SUPERSONIC FLIGHT (DEV D, 2 HR)	85 EMERGENCY PROCEDURES (DEV 2, 2 HR)	** 86 NORMAL & EMERGENCY PROCEDURES (CREW) (DEV 2, 2 HR)	87 BRIEFING (DEV B, 1 HR)
E		85 SUPERSONIC FLIGHT (DEV 0, 2 HR)	86 EMERGENCY PROCEDURES (DEV 2, 2 HR)		87 BRIEFING (DEV B, 1 HR)
F				80 IKB DATA (TABLE CLEAR) (DEV 0, 2 HR)	81 IKB DATA (TABLE CLEAR) (DEV 2, 1 HR)
G	91 BRIEFING (DEV B, 1 HR)	92 NAVIGATION PRACTICE (DEV 3, 3 HR)	93 DEBRIEFING (DEV B, 1 HR)	94 IKB DATA (TABLE CLEAR) (DEV 0, 2 HR)	95 IKB DATA (TABLE CLEAR) (DEV 2, 1 HR)
H	102 BRIEFING (DEV B, 1 HR)	103 NAVIGATION PRACTICE (DEV 3, 3 HR)	104 DEBRIEFING (DEV B, 1 HR)	105 IKB DATA (TABLE CLEAR) (DEV 0, 2 HR)	106 IKB DATA (TABLE CLEAR) (DEV 2, 1 HR)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88 ALL MANEUVERS DEV 3 3 HR
89 DEBRIEFING DEV B 1 HR
90 GRAVITY RELEASE SRAM DEV D 2 HR
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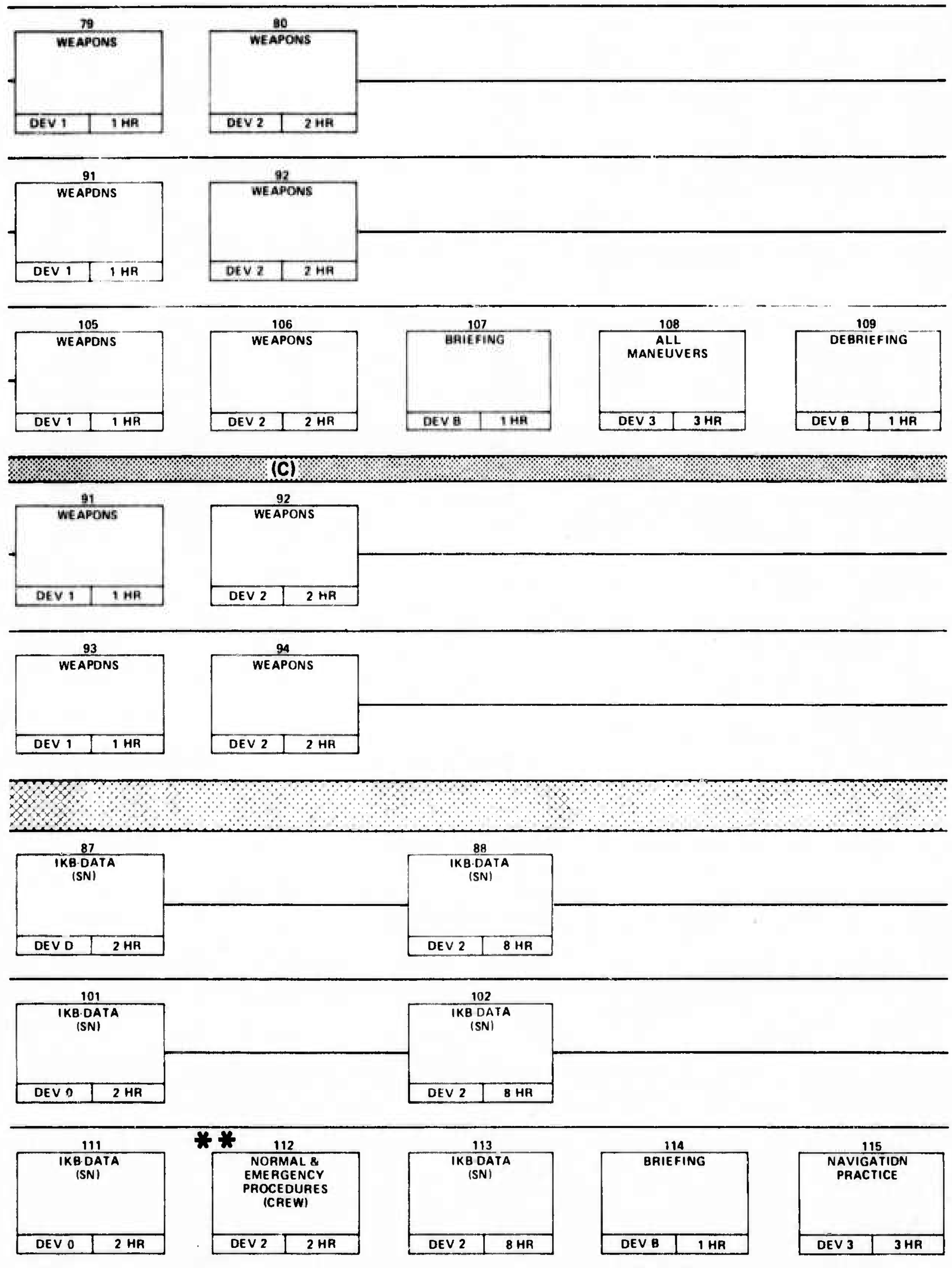
102 DEBRIEFING DEV B 1 HR
103 GRAVITY RELEASE SRAM DEV O 12 HR
**
104 NDRMAL & EMERGENCY PROCEDURES (CREW) OEV 2 2 HR
(C)
(C)
88 ALL MANEUVERS OEV 3 3 HR
89 DEBRIEFING DEV B 1 HR
90 GRAVITY RELEASE SRAM DEV O 2 HR
88 ALL MANEUVERS DEV 3 3 HR
89 OEBRIEFING OEV B 1 HR
90 GRAVITY RELEASE SRAM OEV O 7 HR
**
91 NDRMAL & EMERGENCY PROCEOURES (CREW) DEV 2 2 HR
92 GRAVIETY RELEASE SRAM DEV D 5 HR
82 IKB DATA (NUCLEAR STDRES) OEV 0 2 HR
83 IKB DATA (NUCLEAR STORES) DEV 2 3 HR
**
84 NORMAL & EMERGENCY PROCEOURES (CREW) DEV 2 2 HR
85 BRIEF/DEBRIEF DEV B 1 HR
86 NAVIGATIDN PRACTICE OEV 3 2 HR
96 IKB DATA (NUCLEAR STORES) DEV 0 2 HR
97 IKB OATA (NUCLEAR STORES) DEV 2 3 HR
**
98 NORMAL & EMERGENCY PROCEOURES (CREW) DEV 2 2 HR
99 BRIEF/DEBRIEF OEV B 1 HR
100 NAVIGATIDN PRACTICE DEV 3 2 HR
107 IKB DATA (NUCLEAR STDRES) DEV 0 2 HR
108 IKB DATA (NUCLEAR STDRES) DEV 2 3 HR
109 BRIEF/DEBRIEF OEV B 1 HR
110 NAVIGATIDN PRACTICE DEV 3 2 HR


79
WEAPONS
DEV 1
1 HR
80
WEAPONS
DEV 2
2 HR
91
WEAPONS
DEV 1
1 HR
92
WEAPONS
DEV 2
2 HR
105
WEAPONS
DEV 1
1 HR
106
WEAPONS
DEV 2
2 HR
107
BRIEFING
DEV B
1 HR
108
ALL MANEUVERS
DEV 3
3 HR
109
DEBRIEFING
DEV B
1 HR
(C)
91
WEAPONS
DEV 1
1 HR
92
WEAPONS
DEV 2
2 HR
93
WEAPONS
DEV 1
1 HR
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WEAPONS
DEV 2
2 HR
87
IKB DATA (SN)
DEV D
2 HR
88
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DEV 2
8 HR
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DEV 0
2 HR
102
IKB DATA (SN)
DEV 2
8 HR
111
IKB DATA (SN)
DEV 0
2 HR
**
112
NORMAL & EMERGENCY PROCEDURES (CREW)
DEV 2
2 HR
113
IKB DATA (SN)
DEV 2
8 HR
114
BRIEFING
DEV B
1 HR
115
NAVIGATION PRACTICE
DEV 3
3 HR

A	81 BRIEFING (DEV B, 1 HR)	82 ALL MANEUVERS (DEV 3, 4 HR)	83 DEBRIEFING (DEV B, 1 HR)	84 SECURE VOICE (DEV O, 1 HR)	85 POSITIVE CONTROL & LAUNCH (DEV O, 2 HR)
B	93 BRIEFING (DEV B, 1 HR)	94 ALL MANEUVERS (DEV 3, 4 HR)	95 DEBRIEFING (DEV B, 1 HR)	98 SECURE VOICE (DEV 0, 1 HR)	97 POSITIVE CONTROL & LAUNCH (DEV O, 2 HR)
C	110 BRIEFING (DEV B, 1 HR)	111 ALL MANEUVERS (DEV 3, 4 HR)	112 DEBRIEFING (DEV B, 1 HR)	113 SECURE VOICE (DEV 0, 1 HR)	114 POSITIVE CONTROL & LAUNCH (DEV O, 4 HR)
	(C)	(C)	(C)		
D	93 BRIEFING (DEV B, 1 HR)	94 ALL MANEUVERS (DEV 3, 4 HR)	95 DEBRIEFING (DEV B, 1 HR)	96 SECURE VOICE (DEV 0, 1 HR)	97 POSITIVE CONTROL & LAUNCH (DEV O, 2 HR)
E	95 BRIEFING (DEV B, 1 HR)	96 ALL MANEUVERS (DEV 3, 4 HR)	97 DEBRIEFING (DEV B, 1 HR)	98 SECURE VOICE (DEV 0, 1 HR)	99 POSITIVE CONTROL & LAUNCH (DEV D, 4 HR)
F		89 PERFORMANCE/ MISSION PLANNING (AR) (DEV O, 1 HR)	90 SECURE VOICE (DEV D, 1 HR)	91 POSITIVE CONTROL & LAUNCH (DEV O, 2 HR)	92 PRE-FLIGHT (DEV A/C, 2 HR)
G		103 PERFORMANCE/ MISSION PLANNING (AR) (DEV 0, 1 HR)	104 SECURE VOICE (DEV 0, 1 HR)	105 POSITIVE CONTROL & LAUNCH (DEV 0, 2 HR)	106 PRE-FLIGHT (DEV A/C, 2 HR)
H	116 DEBRIEFING (DEV B, 1 HR)	117 PERFORMANCE/ MISSION PLANNING (AR) (DEV 0, 1 HR)	118 SECURE VOICE (DEV 0, 1 HR)	119 POSITIVE CONTROL & LAUNCH (DEV 0, 2 HR)	120 PRE-FLIGHT (DEV A/C, 2 HR)

No.	Session	Device	Time
1	NORMAL & EMERGENCY PROCEDURES	DEV 2	4 HR
2	MISSION PLANNING	DEV B	8 HR
3	BRIEFING	DEV B	2 HR
4	FULL MISSION	DEV 4	5 HR
5	DEBRIEFING	DEV B	2 HR
6	MISSION PLANNING	DEV B	6 HR
7	BRIEFING	DEV B	2 HR
8	WEAPONS (TO, LDG, AR, TF)	DEV 4	5 HR
9	DEBRIEFING	DEV B	2 HR
10	EMERGENCY PROCEDURES	DEV 2	2 HR
11	MISSION PLANNING	DEV B	4 HR
12	BRIEFING	DEV B	2 HR
13	PRE-FLIGHT	DEV A/C	1 HR
14	FULL MISSION	DEV A/C	5 HR
15	DEBRIEFING	DEV B	2 HR
16	EMERGENCY PROCEDURES (NIGHT EMPHASIS)	DEV 2	2 HR
17	MISSION PLANNING	DEV B	4 HR
18	BRIEFING	DEV B	2 HR
19	FULL MISSION (NIGHT)	DEV 4	6 HR
20	DEBRIEFING	DEV B	2 HR
21	MISSION PLANNING	DEV B	4 HR
22	BRIEFING	DEV B	2 HR
23	PRE-FLIGHT	DEV A/C	1 HR
24	FULL MISSION (NIGHT)	DEV A/C	6 HR
25	DEBRIEFING	DEV B	2 HR
26	MISSION PLANNING	DEV B	4 HR
27	BRIEFING	DEV B	2 HR
28	60-4 SIMULATOR CHECK	DEV 4	5 HR
29	DEBRIEFING	DEV B	2 HR
30	EMERGENCY PROCEDURES	DEV 2	2 HR
31	MISSION PLANNING	DEV B	4 HR
32	BRIEFING	DEV B	2 HR
33	PRE-FLIGHT	DEV A/C	1 HR
34	FINAL 60-4 CHECK	DEV A/C	5 HR
35	DEBRIEFING	DEV B	2 HR

CCTS GRADUATION

3.4.3.2 Proficiency Maintenance Training (PMT)

The training that continues after the crewmembers graduate from CCTS is primarily for the purposes of maintaining the proficiency of combat ready crews. This training is also referred to as operational readiness training (ORT). Once the initial (transition) training is completed, this continuation training is required to assure that previously acquired skills and knowledges are retained. In addition, PMT involves the instruction of new information and techniques as they develop (e.g., air vehicle hardware and software changes).

Rather than a sequence of instructional blocks, the PMT courses are periodically scheduled training sessions. The instructional content of the session is determined by the crew's (or crewmember's) particular capabilities and limitations. That is, there are often large individual differences among crewmembers with respect to their ability to retain various types of information and maintain particular skills. The computer-managed instruction system is of particular value in evaluating individual and crew performance data so that the PMT training sessions may be structured around the crewmember's (crew's) particular deficiencies.

There are four major categories of instruction into which PMT can be grouped. The first category involves instruction on updates to the B-1 air vehicle system. This includes both systems (e.g., controls and displays) and procedures (flight handbook) changes. This, as well as refresher instruction, is done in Device 0 (Carrel). The term "academic" instruction has often been used to represent this type of material.

The second category of instruction pertains to the acquisition of new procedure skills and the rehearsal of previously acquired normal and emergency procedures. In the research literature involving complex tasks, it has been illustrated that the type of behaviors referred to here as procedural tasks suffer from more rapid "forgetting" than the other types of tasks. Procedural tasks also tend to be high in criticality. It is highly desirable, therefore, that normal and particularly emergency procedures be practiced with relatively short inter-session intervals. This practice is accomplished in Device 2 (Procedures Trainer).

The third area of PMT involves the practice of interactive tasks that require complex perceptual-motor behavior and "real-time" decision making. These behaviors are practiced in Device 3 (Part-Mission Trainer), and the air vehicle. The training time spent in the air vehicle is used to train only those behaviors that cannot be practiced satisfactorily in ground-based devices.

The fourth category of PMT involves an integrated crew rehearsal of a complete Emergency War Order (EWO) mission. This training occurs in Device 4 (Full-Mission Simulator) and to a limited extent in the air vehicle. The air vehicle is limited in its capability to provide this type of training as discussed in Section 3.3.5.

The requirement for standardization of performance evaluation criteria are very important for both operational effectiveness evaluation as well as PMT "course" evaluation and modification. An example of this latter concern is the evaluation of instructor and examiner reliability across the entire B-1 training system (CCTS and PMT). As discussed in the section on device requirements, the format used for performance measuring and recording must be compatible at both CCTS and PMT, as well as with the analysis facilities of the SAC ISD team.

There are many configurations that PMT can assume. One configuration involves the crewmembers performing all of their proficiency training at their individual MOB. This is generally referred to as "decentralized" PMT. In this configuration, each MOB must have sufficient numbers of all of the devices to support PMT. An alternative configuration involves all of the crews traveling (TDY) to a "centralized" location for periodic PMT. In this case,the individual MOB has no training devices other than the air vehicle. The central training facility (i.e. CCTS), however, has sufficient numbers of devices to support PMT for the entire B-1 fleet.

The former (decentralized) configuration has the advantage of fewer personnel logistics problems and lower TDY costs. The former also has the pedagogical advantage of utilizing temporally spaced practice rather than massed practice (e.g., once a month versus three times once every quarter). The lesser training effectiveness of the centralized (periodic) training concept results in somewhat more air vehicle flying time being required to maintain proficiency. However, significant initial investment cost savings and logistical support advantages can be experienced in the centralized configuration. For example, more efficient utilization can be gained by centralization when each MOB requires only partial utilization (e.g., 1/3 of a Full-Mission Trainer-Device 4). Similarly, the logistics involved in the supply of replacement and spare parts, as well as maintenance personnel, is an advantage of centralization.

There are obviously many PMT configurations that lie between the totally centralized and decentralized. An example of a partially centralized case is to have the simpler devices (carrels and procedures trainers) at the MOB for frequent utilization, while having the complex devices (Part and Full-Mission Trainers) at only the centralized location to be used on a less frequent basis. This latter case effectively utilizes the lower cost, academic and procedures devices in those behaviors appropriate for the devices requiring more frequent rehearsal to ensure retention. The behaviors practiced in the more costly trainers, on the other hand, are retained longer so less

frequent (e.g., quarterly) practice is appropriate.

Another partially centralized concept consists of a number of "centralized" locations rather than only one, so that some crews require TDY for PMT while others do not. Another aspect of partially centralizing PMT is to have only some of the crews at each MOB travel to a central location. For example, if a MOB requires the use of one and one-half of a certain device, it might be appropriate to have one of those devices at the MOB and send one third of the crews to a centralized training facility. The factors that are affected by these aspects of centralization are the previously discussed travel costs and the logistical support considerations. Through the use of various centralization schemes involving the distribution of individuals, devices, and central locations, optimum utilization of the devices can be established across the B-1 system.

Within these "centralization" configurations, four cases have been selected to represent practicable configurations for B-1 PMT. These configurations are illustrated in Table 5. Case I represents the decentralized case in which each MOB has sufficient training devices to provide PMT. This case requires one five-hour flight per crew per month. These flight hours are assumed to be "training efficient." That is, many of the hours that are logged during missions such as ferrying flights are not considered as providing efficient training.

As previously discussed, PMT curricula are comparable on three points: academic, procedures practice, and "stick time" (time in Devices 3, 4, or airborne). The PMT illustrated in Case I utilizes 8 hours per month of academic training (e.g., one hour sessions, twice per week). Normal and emergency procedures are practiced six hours per month (two hour sessions at approximately 10 day spacings). Stick time for Case I is 17 hours per month (204 hours per year).

The second configuration, Case II, is identical to Case I with the exception that two flights of four hours are used rather than the one five-hour flight in Case I. It is judged that one five-hour flight per month is sufficient to maintain proficiency on the behavioral objectives that cannot be satisfied in ground-based devices. However, Case II corresponds to the current operational concept which cites two four-hour flights per month for PMT.

Case III represents a "partially centralized" configuration. That is, it is centralized with respect to the fact that <u>all</u> crews periodically travel to one or more central base(s) to practice on the part and full mission trainers. It is only "partially" centralized in that the lower complexity devices (carrels and procedures trainers) are located at each of the individual MOBs. The academic and procedures rehearsal times are the same as in

Table 5
PROFICIENCY MAINTENANCE TRAINING CONCEPTS
(HOURS PER MONTH)

	DECENTRALIZED		PARTIALLY CENTRALIZED	REDUCED DEVICES AT MOB'S
	(RECOMMENDED)	(ALTERNATE)		
CARRELS	8, 1-HR SESSIONS	8, 1-HR SESSIONS	8, 1-HR SESSIONS	8, 1-HR SESSIONS
PROCEDURES TRAINERS (EACH: P/CP, OSO, & DSO)	6, 1-HR SESSIONS	6, 1-HR SESSIONS	6, 1-HR SESSIONS	6, 1-HR SESSIONS
PART-TASK TRAINER (EACH: P/CP, OSO, & DSO)	3, 2-HR SESSIONS	(3, 2-HR SESSIONS)	* 3, 3-HR SESSIONS (AT CENTRALIZED BASE) (QUARTERLY)	0
FULL-MISSION TRAINER	1, 2-HR SESSION 1, 4-HR SESSION	1, 2-HR SESSION 1, 4-HR SESSION	* 3, 4-HR SESSIONS (AT CENTRALIZED BASE) (QUARTERLY)	0
AIR VEHICLE	5 (1 FLIGHT)	8 (2 FLIGHTS)	10 (2 FLIGHTS)	18 (3 FLIGHTS)

*HOURS PER QUARTER

Case I (eight and six hours, respectively). In addition, the "stick time" per year is approximately the same as Case I (204 hours). However, in Case II, only the air vehicle flight sessions are evenly distributed over time (approximately two week intervals) with the part and full mission trainer sessions being massed together on a quarterly basis.

The fourth configuration represents a situation where the acquisition costs are minimized by not using any complex devices for PMT. However, proficiency is maintained through greater use of the air vehicle which results in very high life-cycle costs. The academic and procedures times for this case are the same as the other configurations. The "stick time" is also approximately the same (211 hours/year). There are training limitations to this case which are discussed in Section 3.4.2.

The times illustrated in Table 5 were determined on the basis of a review of other military proficiency programs in conjunction with the B-1 behavioral objectives for which proficiency must be maintained. Particularly with respect to PMT, subsequent program evaluation and refinement by an ISD team is essential.

3.4.3.3 Upgrade Training--Copilot to Pilot

Two alternative approaches to copilot upgrade training were considered. One approach involved the copilots returning to CCTS for upgrade training. The second approach involved the upgrading of copilots to pilots at the MOB during PMT. The primary advantage of the first alternative is crew-coordination involved in experiencing the other crewmembers' "idiosyncrasies" (as opposed to equipment dependencies). The advantage of the second alternative is cost savings.

The training objectives relating to systems and procedures knowledge are the same for both pilots and copilots. Both of the crewmembers graduate from CCTS with this knowledge. The differences between the postions reside in the "proficiency" levels (criteria) that they attain in precise perceptual-motor behaviors (e.g., refueling and landing). That is, the copilot has all of the "knowledge" required of the pilot but requires additional "experience" to meet the criteria to be met by pilots.

Particularly due to the symmetry of the instrumentation (including controls) within the B-1, copilots receive this experience through operational (PMT and operational readiness inspection) activities. It is recommended, therefore, that pilot upgrade training (PUP) be accomplished during PMT as opposed to TDY at CCTS. That is, the upgrade training is a natural result of normal proficiency training during which time the copilots are given sufficient time to increase their proficiency to pilot standards. The crew coordination aspect of having the upgrade training at the CCTS are outweighed by the cost and scheduling implications of that approach.

Section 4

ANALYSIS OF TRAINING SYSTEMS

4.1 INTRODUCTION

4.1.1 General Discussion

Analysis of a system is performed to discover the relationship between the performance of its components and the overall system performance. In this training system analysis, the overall performance, and the proficiency of the graduates is taken as given. That is, all graduates should have demonstrated that they possess the skills and knowledge needed to successfully perform their roles in the operation of the air vehicle. A measure of effectiveness of next importance for this study then is the cost of the system. This analysis has considered that the most significant cost is that of the 10-year life cycle. The particular period which we identify as the life cycle is 1980 through the end of 1989. Costs are also broken out by categories in RDT&E, O&M, etc.

The parameters of the problem are determined by externally imposed policy, as well as (internally) by the design of the training system in the instructional system design. The analyst manipulates a model of the system by changing its parameters (both external and internal) in order to understand the system and thereby to optimize the measure of effectiveness. In the present case, one hopes to find the training system which has the least cost. Manipulation of the external parameters can provide data for other analyses which seek to determine the optimum of some more extensive system, for example, the total B-1 aircraft systems, or the Air Force as a whole.

The results of the instructional system design provided a limited number of parameters which could be manipulated. Typically, the media which were specified for a given instructional block were limited to a single device. The given device or other devices in an ascending hierarchy of more sophisticated and expensive devices could be used. However, the cost associated with the next level of complexity is an order of magnitude larger than the given device. Thus, there is little likelihood that substitution of more complex devices for simpler devices could lower overall costs. Substitution of time in an aircraft for time in a trainer was one possibility which was explored, but no immediate savings were possible.

Results were obtained for variation in the crew ratio and for several basing concepts. These results revealed that the costs for any of the basing concepts could be made comparable and that the number of trainees (through the action of the crew ratio parameter) had a strong influence on life-cycle costs. Cost details of the results are contained in Appendix A, Volume 2.

4.1.2 Approach

The approach to the analysis of the B-1 aircrew training system was to compare alternatives to a baseline system concept . The baseline incorporated Air Force preferred or given B-1 operational parameters and the programmed-derived recommended training system. The effects of other system parameters are treated as perturbations on the basic concept. No real distinction is made between externally influenced parameters and internally influenced parameters, since the command level at which control is exercised should be obvious. The methodology is documented in sufficient detail, and the computer programs are available to the Air Force so that other concepts and parameter values can be examined easily. This study has provided a number of results, a methodology for performing an economic analysis, data required for further analysis and an automation of the principal computations.

The analysis of a training system concept is in terms of resource use and is performed by the TRAM or TROLIE programs. The assignment of costs is accomplished by Phase 4 of TRAM which is also used by the TROLIE program. TRAM and TROLIE are described in Technical Memoranda SAT-5 and SAT-6.

The approach to deriving cost data, the values used and detailed listings of the results of the economic analysis are contained in Appendix A (Vol. 2).

The principal alternatives with respect to media considered involve the substitution of the B-1 aircraft for the full-mission trainer and part-mission trainer as a part of the proficiency maintenance program. Using a roughly 1:1 trade-off between ground trainer and aircraft (which is a conservatively low estimate, considering the training to be accomplished), it was found that minimization of aircraft time is equivalent to optimization of the system.

The number and time phasing of crew training is determined by the number of combat aircraft and the crew ratio, the ratio of qualified combat crews to combat aircraft, and by attrition. It was found that the life cycle cost varies strongly with the crew ratio since the operations and maintenance costs associated with proficiency maintenance flying dominate the life-cycle cost.

4.2 BASELINE SYSTEM

4.2.1. Baseline Concept

The baseline system provides a benchmark with which other candidate system concepts can be compared. The baseline is designed to incorporate as closely as possible the current B-1 operational concepts and to represent the independently derived, lowest cost training concept. Comparison of the cost of the baseline system with the cost of other candidate systems provides a means for evaluating non-monetary costs. For example, the baseline system

uses one training flight per month for Proficiency Maintenance Training. This is the major difference between the baseline system and the current concept of operations. Comparison of the cost of the baseline system with the alternative system using two flights per month reveals the cost of the additional flight. The decision-maker can then weigh the value of the extra flight with respect to its marginal cost to determine if he wishes to continue the two-flight per month policy.

4.2.2. Description of the Baseline System

The baseline system involves 7 MOBs. Six of the MOBs have a full wing (30 UE aircraft). The CCTS base has a CCTS squadron (15 UE aircraft) and a squadron of combat aircraft. The first four vehicles are research and development prototypes. The first mission-capable aircraft is delivered to the CCTS. Aircraft are then delivered at an accelerating rate up to a maximum of 4 per month to the 6 MOBs with full wings, one base at a time. Finally, the squadron of combat aircraft are delivered to the CCTS base. Tables 6 and 7 illustrate the B-1 activation schedule and establishment of bases, respectively. CCTS training demands for "new" crews occur upon delivery of aircraft to a base. Later, CCTS training demands occur for replacement crews in order to maintain the desired crew ratio when attrition occurs.

Attrition is modeled as a percentage of the crews at a given base. The nominal tour of duty is three years. For a variety of reasons, attrition actually starts immediately upon graduation. As a crude approximation to these effects, a delay of two years is introduced. This results in an expected tour of duty for all trainees of about three years, depending upon the details of the delivery schedule for the particular base. In steady state , the average tour of duty is the reciprocal of the attrition rate. If all aircraft are delivered at about the same time, the average tour of duty of the initial crews is 3.2 years. The steady state tour of duty is based upon a 30% attrition rate so the steady state tour of duty is 3-1/3 years.

In addition to attrition losses, the supply of copilots suffers additional attrition as candidates for upgrading to pilot are selected. An additional 20% of the copilots are assumed to undergo attrition for this purpose. Thus, in the steady state, 2/3 of the pilots will be obtained by upgrading of copilots. The copilot average tour of duty is reduced to two years in steady state.

The training program for a given position is called a course. Within a course, syllabi for a number of tracks were planned. A separate track is defined for each of the major sources of trainees available.

The sources of trainees are prioritized for each crew position as illustrated in Table 8. The training system calls upon the highest priority sources until it is exhausted, then goes to the next highest, etc. The sources and priorities are given in Table 9 as derived from discussions with SAC personnel. For example, the introduction of UPTs into the B-1 training program is delayed until 1983. This is reflected in the time-phased demand

Table 6

B-1 Activation Schedule

Start Date	End Date	Rate/Month	Total in Period	Destination
Apr 79	Dec 79	--	5	R&D
Jan 80	May 80	1	5	CCTS
Jun 80	Oct 80	2	10	CCTS
Nov 80	Nov 80	2	2	
Dec 80	Mar 81	3	12	1st Operational Wing
Apr 81	Apr 81		1	
Apr 81	(Final Delivery)	4	180	Other MOBs (15/wing 2/wings/base)

Table 7

Establishment of Bases

Base	B-1 Deliveries
CCTS	1980
1	1980-1981
2	1981-1982
3	1982
4	1982-1983
5	1983-1984
6	1984
7 (15 UE co-located with CCTS)	1984-1985

Table 8

Source Priority and Capacity

Priority	Pilot	Copilot	OSO	DSO
1st	Copilot 20% of fleet	B-52 Copilot 96/year	FB-111 R/N 12/year	B-52 EWO 96/year
2nd	FB-111 Pilot 12/year	UPT Unlimited avail at 1982	B-52 R/N 192/year	EWOT Unlimited
3rd	B-52 Pilot 96/year	KC-135 Copilot 360/year*	UNT* Unlimited	
4th	KC-135 Pilot Unlimited**			

* Never used

** Limited use

Table 9

Overall Training Demand Schedule

Year	UE Deliveries*	Total UE AV's	Total Crews	New Crews Trained	Rep Crews Trained	Total Crews Trained	Copilot Upgrades
1980	5	5	10	10	0	10	0
1981	45	50	100	90	0	90	0
1982	48	98	196	96	3	99	1
1983	48	146	292	96	30	126	10
1984	48	194	388	96	59	155	20
1985	1	195	390	2	88	90	29
1986	-	195	390	-	116	116	39
1987	-	195	390	-	117	117	39
1988	-	195	390	-	117	117	39
1989	-	195	390		117	117	39

* Excluding CCTS

schedule (Table 9) and the availability of the source (Table 10). B-1 copilot upgrade to pilot is preferred over all sources since no CCTS training is required for this transition given that the copilot has served as a copilot for two years (which is guaranteed by the attrition model assumed).

Resource use is determined by the instruction system. In the case of the TRAM program, resource use is specified for each instructional block. In the case of TROLIE, the resources used in each track are used as input. The resource use for each CCTS track is given in Table 11 (see Section 3.4.3). Note, however, that the data in this table cannot be used directly since some devices are used by a single crewmember, while others are used by two or more simultaneously. This is particularly the case for the pilot and copilot who share time in the trainers. For costing purposes, these duplicated times are attributed to the pilot.

The recommended PMT concept is described in Section 3.4.3.2. This is the completely decentralized concept. The outstanding feature of this concept is not decentralization, but the low number of flight hours required. Flight time is reduced by the extensive and regular use of trainers at the MOBs. In spite of the high acquisition operating expenses for the trainers, the cost of flight time dominates the life cycle cost.

The resource use at the CCTS base by the operational squadron is joined with that of the CCTS. By assuming that the MOB at the CCTS base is deployed last, the requirement for PMT on the CCTS devices is built up just as the requirement for CCTS initial crews goes to zero. This approach confounds the separation of PMT from CCTS costs but reduces the acquisition costs through more efficient use of the available training devices.

4.2.3 Devices Required by the Recommended Instructional System (with Baseline Assumptions)

The number of training devices required to support the recommended instructional system is shown in Table 12. The additional devices required at the CCTS, if a co-located operational squadron is to share resources with the CCTS is shown separately from the CCTS requirements alone.

The maximum use of an instructional device is known as its yield. The yield of various devices varies with the type of device. The trainers at MOBs are programmed for greater yield than the trainers at CCTS since a certain amount of make-up work and instructor training is accomplished at CCTS. Table 13 lists the assumed yield of each type of device.

Table 10

Source Use

Year	Copilots	Pilots FB-111	Pilots B-52	Pilots KC-135	Copilots B-52	Copilots UPT	Copilots KC-135	OSO FB-111	OSO B-52	BNT	DSO B-52	DSO EWOT
1980	-	10	-	-	10	-	-	10	-	-	10	-
1981	-	12	78	-	90	-	-	12	78	-	90	-
1982	2	12	85	-	96	5	-	12	87	-	96	3
1983	20	12	94	-	96	50	-	12	114	-	96	30
1984	39	12	96	8	96	98	-	12	143	-	96	59
1985	58	12	20	-	96	52	-	12	78	-	96	
1986	78	12	26	-	96	98	-	12	104	-	96	20
1987	78	12	27	-	96	99	-	12	105	-	96	21
1988	78	12	27	-	96	99	-	12	105	-	96	21
1989	78	12	27	-	96	99	-	12	105	-	96	21

Table 11

Resource Use by Track (hours)*

Resource	Briefing Room	Carrel	Familiar-ization	Procedures Trainer P/CP	Procedures Trainer OSO	Procedures Trainer DSO	Part-Mission Trainer P/CP	Part-Mission Trainer OSO	Part-Mission Trainer DSO	Full-Mission Trainer	B-1 Missions
Pilot Trainees											
FB-111	89	43	31	34	2		29			21	4 Missions
B-52	96	40	43	38	2		37			21	4 Missions
KC-135	108	68	48	38	2		48			21	5 Missions
Copilot Trainees											
B-52	2	40	43		2						
UPT & KC-135	2	68	48		2						
OSO Trainees											
FB-111	14	78			81			24			
B-52	19	84			84			35			
UNT	27	110			86			50			
DSO Trainees											
B-52	35	50				40			50		
EWOT	45	60				50			65		

* To exercise TRAM/TROLIE, use of a resource is attributed only to the pilot when it is used simultaneously by other crew members.

TABLE 12

Number of Devices Required

DEVICE	FACILITY: CCTS Without A Co-located MOB	CCTS With Co-Located MOB (15 UE)	MOB (30 UE)
0 - Carrel	9	13	8
1 - Familiarization	4	4	0
2 - Procedures P/CP	2	2	1
OSO	3	3	1
DSO	2	2	1
3 - Part-Mission P/CP	1	2	1
OSO	1	2	1
DSO	2	2	1
4 - Full-Mission	1	2	1

TABLE 13

Device Yield

Device	Yield (Hrs/Year)
Briefing Room	3000
General Purpose Carrel	3000
Familiarization Trainer	3000
Procedures Trainers	4000
Part-Mission Trainers (at CCTS)	4000
Part-Mission Trainers (at MOB)	5000
Full-Mission Trainers (at CCTS)	4000
Full-Mission Trainers (at MOB)	5000

4.2.4 Personnel

Instructors are assumed to have the rank of Major. Half of an instructor's time is attributed to overhead consisting of analysis of trainee progress, upgrading of instructional material (excluding actual preparation), other military duties, leave, etc. Instructor time associated with each device is given in Table 14.

The general-purpose carrel room has a GS-11 technician assigned. The familiarization trainer has 20% of a GS-11 technician assigned. Other devices assume technician costs as a part of the O&M costs.

Table 14

Instructor Support by Device

Device	Full Crew	Pilot-Copilot Pair	Copilot-Copilot Pair	Single Trainee
Briefing Room-General	IP, IOSO, IDSO	1 IP	1 IP	1 Instructor
Briefing Room-MSN Plan	1/6 of (IP, IOSO, IDSO)	--	--	--
Full-Mission Trainer	IP, IOSO, IDSO	--	IP	--
Part-Mission Trainer	--	IP	IP	--
Procedures Trainer	1/2 Instructor		1/2 IP	1/2 Instructor
Aircraft	2 Instructors	IP	IP	--

IP = Instructor Pilot

IOSO = Instructor OSO

IDSO = Instructor DSO

Instructor = any of the above

4.2.5 Trainer Maintenance Personnel

In the course of the SAT analysis, trainer maintenance requirements have been considered and have led to the following conclusions regarding the type of personnel to be employed for that function. The basic problem is to choose the appropriate point on the continuum, which goes from all-contractor personnel (presumably the contractor who built the trainer) to all-in-house personnel (Air Force personnel trained in hardware and/or software maintenance of training devices). These factors are generally those considered:

1. In-house personnel need to be replaced more often than do contractor personnel (due to attrition, etc.).

2. Contractor personnel have better sources of technical knowledge and replacement parts.

3. Contractor personnel are placed in an unduly advantageous position to monopolize further procurements and modifications.

Calspan advocates a compromise position, in combination with what is believed to be a Department of Defense trend towards the purchase of warranties for trainers. It is apparant that contractor personnel are most effective in repairing major malfunctions, but are not necessarily more effective than in-house (Air Force) personnel in day-to-day software and hardware maintenance. For the purpose of major modifications to the trainer system, a combination of the contractor's knowledge of the technical nature of the modification can be efficiently coupled with the in-house knowledge of the operational requirements.

The recommended maintenance concept is therefore:

1. Purchase warranty coverage to provide contractor personnel for the unscheduled maintenance and repair.

2. Employ contractor personnel to assist in-house personnel during the installation of the system and subsequent major modifications.

3. Use in-house personnel for routine maintenance and modifications.

This arrangement tends to optimize each of the factors mentioned at the start of this section, namely:

1. In-house personnel will tend to stay in the service longer since there is no ready-made (nor economically secure) job waiting for them with the contractor (i.e., doing the same job in the same place, but as a civilian).

2. Contractor personnel are called in only when their technical expertise is needed.

3. Contractor personnel are not placed in the position of being the only individuals who know the complexities of the system, nor do they become especially privy to privileged information regarding future plans of the Air Force.

In order to maintain the greatest flexability in the manipulation of the data, trainer O&M costs are carried as a dollar cost without specific manning associated with the devices.

4.3 COST CATEGORIES

The costs for a system can be organized in many ways. The particular organization used here is based in part on Air Force methodology and in part on the need to provide simple algorithms for mechanization of the computation. Details on the techniques used to estimate the parts of the system are given in Appendix A.

In general, a first unit hardware cost must be estimated for each device. Other costs which can be directly associated with the development, acquisition and operation of the device are calculated from this by cost estimating relationships (CERs). Instructors required to teach the courses are then estimated. Facilities costs are obtained by considering the type of facility required for each of the devices, and the instructor officers needed.

The cost categories considered are RDT&E, acquisition, recurring support, operations and maintenance, facilities acquisition, and instructional material. RDT&E consists of all the costs required to put the first unit in the field, excluding only the instructional material. Acquisition consists of the cost of all remaining systems. Recurring support consists of upgrade and modification costs.

Facilities are estimated as new construction at CCTS, and for the trainers at the MOBs. Existing facilities are assumed for the carrels at the MOBs. Instructors are assumed to be available for PMT in the decentralized concept. The partially centralized concept requires specifically assigned instructions for the PMT training.

Instructional material can represent a significant initial (and recurring) cost and might reasonably be taken as part of RDT&E. However, since there will be a distinct difference in the source of funds for the initial instructional material and the RDT&E, the separation is deemed useful.

A general analysis of the life-cycle costs of the recommended training system, including a detailed breakdown of the costs of the individual components, is given in Appendix A.

4.4 ALTERNATIVE TRAINING SYSTEMS

In addition to the baseline system, the analysis examined modification of the PMT training, alternate basing concept, variation in the crew ratio, and a variation in the replacement model.

4.4.1 Modification of the PMT Training

Threc alternatives were investigated.

- Replacement of the part-task trainer and full-mission trainer time by aircraft time
- Quarterly recurrent training using partially centralized training facilities
- Increased (to AF planning factors) flying time.

Replacement of the part-task trainer and full-mission trainer with aircraft time greatly decreased the acquisition costs. The price one has to pay for this decrease is in an increased cost for flying time (see Appendix A). The increase in O&M completely overshadows the saving in acquisition costs. Similarly, the replacement of the full-mission trainer with aircraft time is not cost effective over the life cycle. Additionally, both of these alternatives are not training effective since many dangerous maneuvers cannot be practiced in the air vehicle.

Quarterly recurrent training at a set of two training bases (e.g., co-located with maintenance depots) introduces increased costs to provide TDY and transportation, as well as special training facility instructors which in the baseline case are assumed to be other combat crewmen. There is a small acquisition saving using this concept. However, it is necessary to increase the flying time in between trips to the training facility. The cost of flying aircraft prevented any saving in life-cycle costs.

The current concept of employment calls for two four-hour missions per month, per crew. The recommended system requires only one five-hour mission. Data contained in Appendix A show the expected result that costs incurred are extremely sensitive to flying time.

4.4.2 Basing Concepts

The basic unit of deployment is the squadron of 15 aircraft. A set of logical combinations of squadrons was established consisting of CCTS and a single squadron of combat aircraft at one base with between 4 and 12 other bases. Calculations showed that one needs about half a full-mission trainer and half a set of part-mission trainers per squadron. Therefore, all basing concepts are about equivalent. The baseline case was the most efficient because it used both types of trainers at nearly full capacity. The single squadron bases used a single full-mission trainer half time and separated it for individual use as a set of part-task trainers for the other half of the time. The 5-base concept needed 1 1/2 full-mission trainers and hence was more expensive than the baseline case. The number of devices required as a function of the number of squadrons at the MOB is illustrated in Table 15. The important point is that basing concepts have only minor effects on life-cycle costs.

Table 15

PMT Facilities

No. of Squadrons at MOB	Carrels	Procedures Trainers	Part-Mission Trainers	Full-Mission Trainers
1	4	1	0	1
2	8	1	1	1
3	12	2	1	2

4.4.3 A Modification in the Replacement Algorithm

Referring again to Table 9, it shows the flow of activity in the training system. A modification in the system was introduced which limited the total full crews trained per year to 120. Attritees which could not be replaced were deferred until the next year. That is, the tour of duty for any airman was extended if he could not be replaced by the limited CCTS. The results of this exercise indicate a total of 70 crew-years were delayed (the same total training was administered). The results further show that each delayed crew-man-year is worth $64,000. Even greater savings are possible if the total trainees are reduced by this technique. It, therefore, appears that strong incentives can be cost-effectively applied to keep airmen from leaving the fleet.

4.4.4 Alert Rate Calculations

Alert rate is a function of maintenance effectiveness and personnel availability. Maintenance effectiveness is reflected in the yield in missions per unit time. During this study, the yield of the aircraft has been expressed in flight hours per unit time and missions per unit time. There are factors which create aircraft down time which are dependent on the number of missions. Refueling, arming, disarming, warm-up cool-down time, etc., reduce aircraft availability in proportion to the number of missions. Overhaul and periodic maintenance and random failures generally contribute to down-time in proportion to aircraft flight hours. Thus, the analysis works with aircraft availability on the basis of flight hours, as well as total flight hours.

Aircraft availability is expressed as:

$$MTU = \frac{(1-A_R)\,Y}{C_R}$$

where
MTU = Maximum training use/unit time/crew
A_R = Alert ratio
Y = Yield in hours/unit time or missions/unit time
C_R = Crew ratio

For the purposes of analysis, alert ratio is assumed to be 60% and a yield of 50 hrs/month or 10 missions. Thus, with the baseline crew ratio of 2, the maximum training use per crew is 2 missions or 10 hours per month.

For the case of variable crew ratio which was investigated, the maximum alert ratio can be increased with decreasing training due to fewer crews to train.

Solving the above formula for alert ratio, we have:

$$A_R = 1 - \frac{UC_R}{Y}$$

where U is the programmed training use. This is $A_R = 1 - \frac{C_R}{10}$ for the baseline system on the basis of missions or flight hours.

However, aircraft availability is not the only limiting factor. This is especially true for the use of a reduced crew ratio.

The model for air crew availability for alert is that the crew will yield 48 weeks of active duty per year. The remaining four weeks are annual leave time. The time required for training on the part- and full-mission trainers and in the aircraft is the programmed time plus, an hour before and after these training events. In addition, instructor time is also charged. It is assumed that an instructor can monitor two trainees in all training. The required hours per active crewman is:

$$R_{HPW} = \frac{(168 \text{ hrs/week})(A_R)}{C_R} \; \frac{52 \text{ weeks/yr}}{48 \text{ work weeks/yr}} + \frac{1.5 \text{ personnel}}{4 \text{ weeks/mo}} (H_A + H_3 + H_4 + 2N) + OMD \text{ hrs/week}$$

or:

$$R_{HPW} = \frac{182\, A_R}{C_R} + \frac{3}{8}\,(H_A + H_3 + H_4 + 2N) + OMD$$

			Baseline Values
where :	H_A =	Hours/crew/mo in the aircraft	5
	H_3 =	Hours/man/mo in a part-task trainer	6
	H_4 =	Hours/crew/mo in a full-mission trainer	6
	N =	Number of training sessions per month	6
	OMD =	Hours/man/week for other military duty, sick leave, etc.	5
	A_R =	Alert Ratio (assumed for this analysis)	0.6
	C_R =	Crew Ratio	2.0

In PMT concepts requiring TDY to a centralized base for recurring training to use Part- or Full-Mission Trainers, (H_3+H_4) is replaced by the average hours (per month) spent on TDY, while N refers only to aircraft sorties.

Assuming that OMD $\approx$ 5 hours/week, this results in 70.5 hours/crew/week. Although this appears to be a large number, it is reasonable considering that crewmen can stand alert for extended periods during which other activities can occur such as the use of carrels or procedures trainers, eating and sleeping. Table 16 illustrates the alert rate and duty week for the four PMT concepts.

4.4.5 Crew Ratio

The crew ratio parameter was systematically varied from the baseline case of 2.0 down to 1.0. Over the 10 year life-cycle, the total number of crews trained is directly proportional to the crew ratio (i.e. half as many crews when the ratio is 1.0). The corresponding total system cost at a crew ratio of 1.0 is about two-thirds of the total cost at a ratio of 2.0. Table 17 illustrates the effect of crew ratio on alert rate.

4.4.6 Conclusions from the Economic Analysis

4.4.6.1 General

A methodology and computer program capable of detailed analysis of B-1 training systems have been developed. This methodology has demonstrated its utility by determining factors which affect the life-cycle and other costs of training.

Specific conclusions are that the recommended (baseline) training system is a very efficient system, that B-1 flying time is the driving factor in the life-cycle costs, that the costs of training are quite sensitive to the number of crews trained, and that basing concepts do not influence training system costs appreciably.

With regard to cost reduction, a number of concepts for proficiency maintenance were evaluated which would limit acquisition costs. The recommended PMT concept is, however, the most efficient on a life-cycle cost basis.

Table 16

Alert Rate Comparison of PMT Concepts*

	Number Missions	A/C Time/ Crew/Mo.	Duty Week (hrs.) at 0.6 Alert Rate**	Based on 10 MSNs/Mo		Based on 50 hrs/Mo	
				Max. Alert Rate	Required Duty Week (hr)	Max. Alert Rate	Required Duty Week (hr)
No Full-or Part-Mission Trainers	3	18	69	0.4	50	0.28	40
Partial Centralization	2	10	77	0.6	77	0.6	77
Increased PMT Missions	2	8	72	0.6	72	0.68	80
Recommended	1	5	70	0.8	89	0.8	89

* Crew ratio assumed to be 2.0 for analysis purposes.

** Alert rate assumed to be 0.6 for analysis purposes.

Table 17

Effect of Crew Ratio Variation for Recommended Concept

Parameters	Crew Ratio 1.0	1.27	1.5	1.75	2.0 (Baseline)
Total full crews trained	520	675	780	918	1037
Max. Alert rate (10 MSN/mo)	0.90*	0.87*	0.85*	0.83*	0.80*
Max. Alert rate (A_r) (50 hrs/mo)	0.90*	0.87*	0.85*	0.83*	0.80*
Duty Week at 0.6 A_r	125	102	89	78	70
A_r for 72-hour week duty	0.31	0.39	0.46	0.54	0.62

* duty week significantly exceeds 72 hour/week.

4.5 FACILITIES REQUIRED TO SUPPORT THE B-1 TRAINING SYSTEM

4.5.1 Introduction

The purpose of this section is to identify and describe the government owned real property requirements implications for support of B-1 aircrew ground training at the Combat Crew Training Squadron (CCTS) and for proficiency ground training at the MOB's. These facility requirements are limited to the CCTS academic-administration and simulator-training buildings and to the MOB facilities to accommodate devices such as carrels, procedure, part-mission, and full mission trainers. Other B-1 operational and training facilities have been defined in the Facilities Requirement Plan (FRP) prepared for the SPO by Calspan in FY 1975. For the purposes of this report, it was assumed that a 15 UE MOB is colocated with the CCTS. The MOB shares the training devices and the corresponding facilities of the CCTS complex.

The three facilities described in this section have been configured to accommodate a level of training activity and number of devices which are indicated by early SAT computations. Later study through the use of the TRAM program resulted in a requirement for slightly different space to house equipment and functions, which are noted.

In order to develop facilities implications, a baseline of physical aspects and support needs for training devices was estimated based upon state-of-art equipment currently in use or in development by the USAF, USN, commercial airlines, aircraft and simulator manufacturers. A broad spectrum of training devices from these sources has been analyzed during the SAT study and a baseline of physical characteristics has been established in order to define the facilities needed to accommodate this equipment, its operations and maintenance.

Flight Simulator Building AD-28-13-103 R-1 for bomber and cargo aircraft was assessed for suitability to support the recommended types of trainers. This building will not, in its present design or an economically feasible modification, support modern-day sophisticated aircrew trainers. For this reason single line sketches and facilities definitions of a CCTS and MOB simulator facilities were developed in accordance with the standard format and content for an Air Force Facilities Requirements Plan.

The Mobile Training Detachment Building AD-38-19-01 is not an adequate structural arrangement for a CCTS academic-administrative facility because it was designed to support maintenance technician training rather than for advanced bomber aircrew needs. Nor does the Flight Training building AD-28-16-19 or any other building described in AFM 88-2 meet the needs of a B-1 CCTS facility. Therefore, a description and single line sketch of the required facilities was developed and is presented in Figure 13.

4.5.2 CCTS ACADEMIC-ADMINISTRATION FACILITY

4.5.2.1 Description

This facility will house the CCTS Squadron Commander, administration, Flight Commanders, Instructors, learning centers with carrels and familiarization trainers, briefing/critique rooms and Instructional System Development (ISD) rooms. A library for instructional material and a computer management instructional room are also provided.

Flight commander and instructor offices are furnished with desks, file cabinets, a table and chairs and blackboard. Briefing rooms are sized for (a) an instructor and one or two students and (b) an instructor crew of three and student crew of four. These larger briefing rooms are used also for mission planning. Because this facility is a squadron headquarters and operations, scheduling activities and a large squadron briefing room are provided which can be subdivided into smaller briefing/mission planning areas by moveable partitions.

B-1 courses, instructional material and methods are developed and evaluated in the ISD space.

A list of devices and functional activities assumed for this portion of the study with required space follows:

	NUMBER	SPACE SF
Carrels	13	1000
Familiarization Trainer	4	480
Instructors' Offices	10 Offices	5270
Briefing/Critique & Mission Planning	11	2320
Library and CMI	2	500
ISD	3	1250
Command and Administration	4	1600
Hall, stairs and storage		3630
Add space taken up by wall for total outside building area		1250
Total Academic-Administration		17,300 SF

4.5.2.2 Personnel to be Accommodated

The table below lists the personnel who will have permanent offices in this building and also shows occupancy on a typical operating shift.

AREAS	PERSONNEL ASSIGNED PERMANENT OFFICES	PERSONNEL ON DUTY DURING A TYPICAL SHIFT
Carrels		13
Trainers		8
Instructors and Flight Commanders	76	35
Briefing/Critique		28
Library	3	1
ISD	13	12
Command & Administration	9	8
	TOTAL	105

4.5.2.3 Interrelationship With Other Facilities

The CCTS academic administration building should be adajacent to or within the same structure as the simulator-trainer complex. To portray an optional arrangement, Figure 13 is a floor plan of academic-administration area, which is configured to become the second floor above the simulators-trainers. It may also be a separate building using the same or a similar floor plan of approximately 17,300 square feet.

4.5.2.4 Schedule

This facility is required six months prior to the arrival of the first B-1 at the CCTS base for instructor training and ISD activities.

4.5.2.6 Utilities

Carrels and familiarization trainers use standard 110V AC and low power users. They do not generate significant heat. Other power and light requirements are for normal administrative offices. Hear and air conditioning are required for comfort and to meet AFM 88-15 standards.

4.5.2.7 Utilization

Academic training and mission planning will be conducted in this facility on two shifts per day, each 6 hours in duration, 5 days a week. Make-up and other rescheduling can be expected to extend these hours to a sixth day. Since flying functions might extend over all parts of the day

and night, full 24-hour availability of the mission planning rooms is required.

4.5.3 CCTS AIRCREW TRAINER BUILDING

4.5.3.1 Description

Trainers will be employed extensively to support a significant portion of the B-1 aircrew training program. The general functions to be performed in this building are student training on devices, maintenance support of the equipment and administration of activities. Detailed descriptions of these functions and devices is provided elsewhere in this report.

4.5.3.2 List of Devices and Space Requirements

The following space requirements have been estimated to accommodate the devices in their operational mode. This space also allows for access and passageways. Because the devices have been only functionally defined in this study, it has been necessary to estimate their physical characteristics, i.e., size, power requirements, etc., from state-of-art hardware knowledge.

Procedures Trainers		Space Each	Total
Pilot/Copilot Incl. station & mini computer	2	300	600
OSO Incl. station & computer	3	240	720
DSO Incl. station & computer	2	240	480
			1800
Part-Mission Trainers			
Pilot/Copilot Incl. station, pumps, console & racks	3	1950	5850
OSO Incl. station, console & racks	3	825	2475
DSO Incl. station, console & racks	4	600	2400
			10,725 SF

* Subsequent analyses indicated that the addition of one Pilot/Co-Pilot Part-Mission Trainer, one OSO Part-Mission Trainer, and one Full-Mission Trainer interface unit are required but have not been included in the facility drawings.

Full-Mission Trainer

When three part-task trainers (pilot/copilot, OSO and DSO), are connected electronically, they make up an integrated full-mission trainer. Full-mission trainer space is accounted for in the totals of the part-mission trainers.

4.5.3.3 Support Areas for Trainers

Briefing 7 rooms		1190
Maintenance and Storage		4950
Administration		450
Halls, Toilets, Stairs		5600
Building Mechanical Utilities		1740
	Support Total	13,930
Wall space to be added for entire building		1560
Total SF for simulator building when measured outside allowing for all of above. Does not include CCTS Academic-Admin. areas	Total	28,015 SF

4.5.3.4 Personnel to be Accommodated

The table below lists the personnel who will operate in this facility during a typical shift.

AREAS	NO. REQUIRED	PERSONNEL PER SHIFT
2/P/CP	2	6
2/OSO	3	6
2/DSO	2	4
3/P/CP	3	9
3/OSO	3	6
3/DSO	4	8
Briefing Rooms	7	20
Maintenance	4	30
Administration	2	5

Personnel to be Accommodated (Continued)

AREAS	NO. REQUIRED	PERSONNEL PER SHIFT
Instructors	-	35
	TOTAL	129

4.5.3.5 Interrelationship with Other Facilities

The CCTS trainer facility (Figure 14) should be located adjacent to or in the same building with the CCTS academics-administration complex. In Figure 13, a floor plan for the CCTS academic-administration space is configured to become the second floor, within the same facility with simulators-trainers.

4.5.3.6 Schedules

This facility will require at least one year for construction after the contract is let. It will be needed nine months prior to arrival of the first B-1 at the CCTS base. After completion, equipment installation and checkout will take three months. It will be operated to train instructors for six months before actual flying begins.

4.5.3.7 Type of Construction

Normal industrial type construction such as metal or concrete to meet AFM 88-15 standards is appropriate for the trainer facility.

The facility must be capable of handling classified material (mission tapes, etc.). The simulator equipment should be designed for maximum suppression or elimination of EMI and RFI. However, experience with other simulators leads to a requirement for building screen shielding to protect the electronic racks from outside interference, and also to prevent possible classified data emissions.

The design should include elevated floors in the computer and trainer rooms. This allows for conditioned air ducting and wiring below the equipment racks. The false floor is readily removable for checks on wiring or rerouting to accommodate equipment changes. Consideration should also be given to the location of dedicated air conditioning packages above the computer rooms. This concept has been found to be more cost-effective in cooling electronic racks than a large central sir system for the entire building. A central system is satisfactory for normal comfort cooling and heating of administrative and maintenance areas.

The pilot/copilot motion platforms for the part-mission trainer require a high bay area on the order of 24 feet clearance. Entrance to these devices should be by enclosed ramp at the level of the cockpits. Consoles for the part-mission trainers should be housed in relatively sound-proof rooms

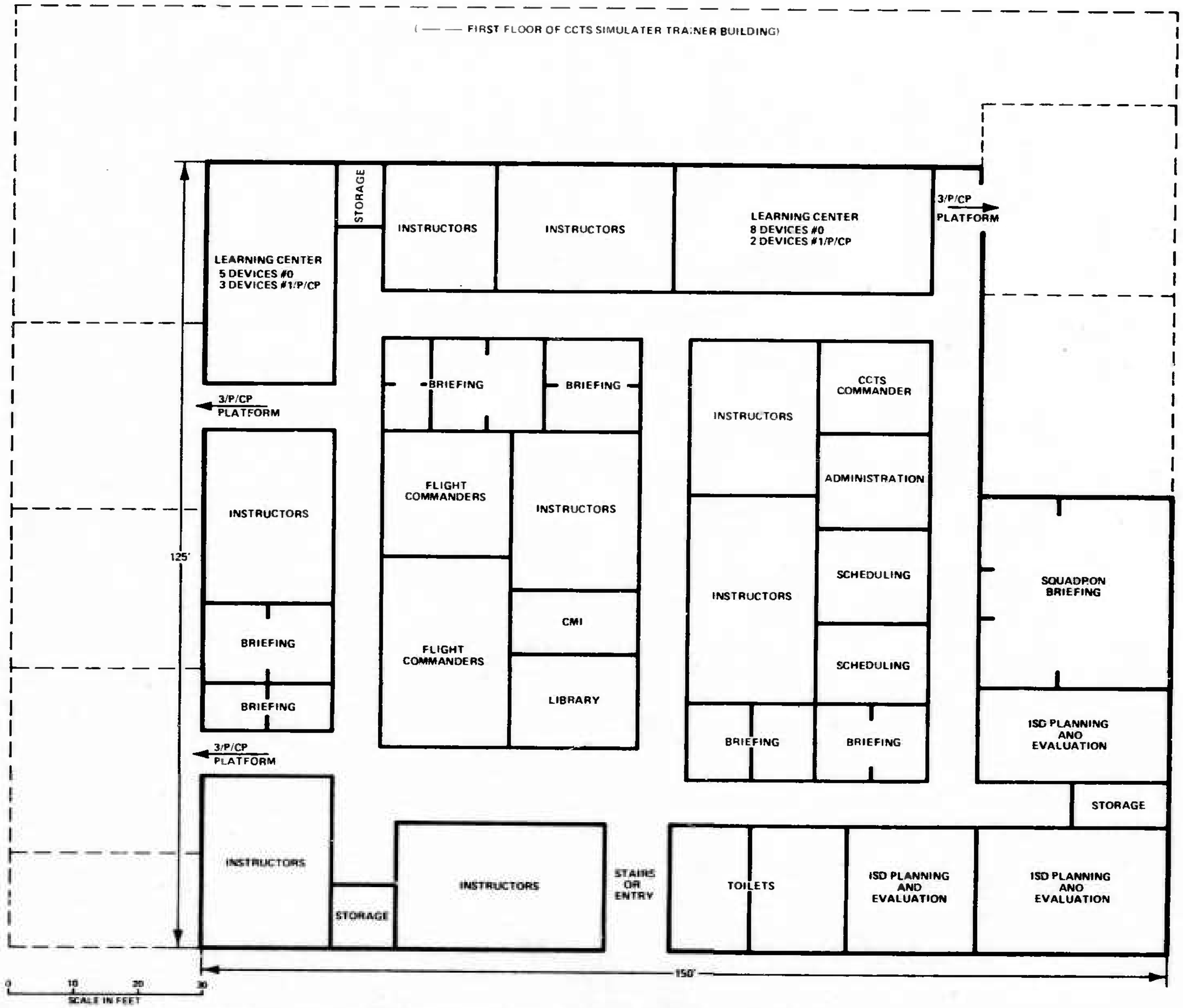

Figure 13 CCTS ACADEMIC-ADMINISTRATION SPACE 18,400 SQ. FT.
(OPTIONS: SECOND FLOOR ABOVE SIMULATOR SPACE, OR SEPARATE FACILITY)

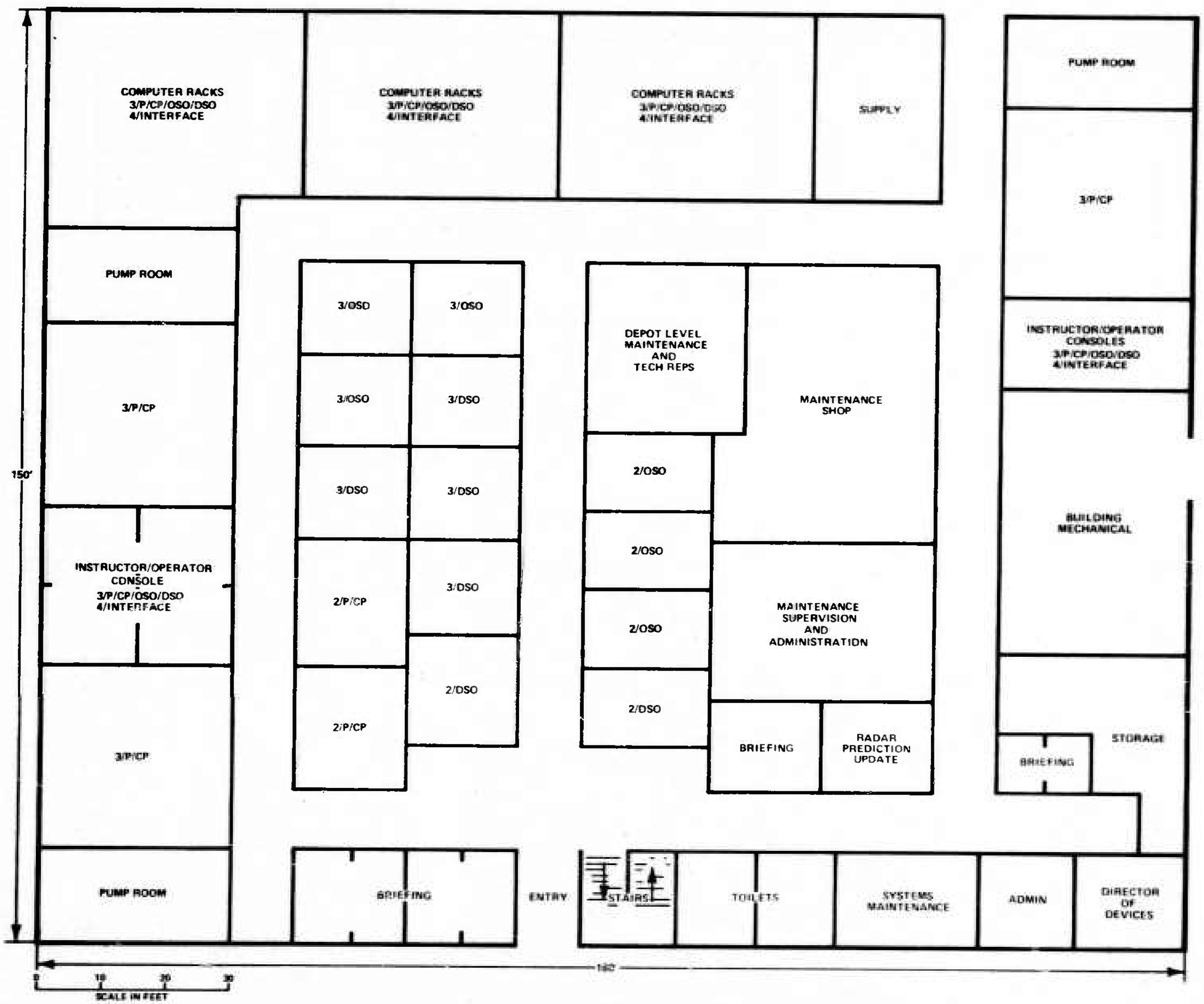

Figure 14 CCTS SIMULATOR-TRAINER BUILDING 28,000 SQ. FT.
[Latest calculations indicate that one each of these devices should be added to this facility: 3/P/CP; 3/OSO; 4/INTERFACE (i.e., computer and software only)]

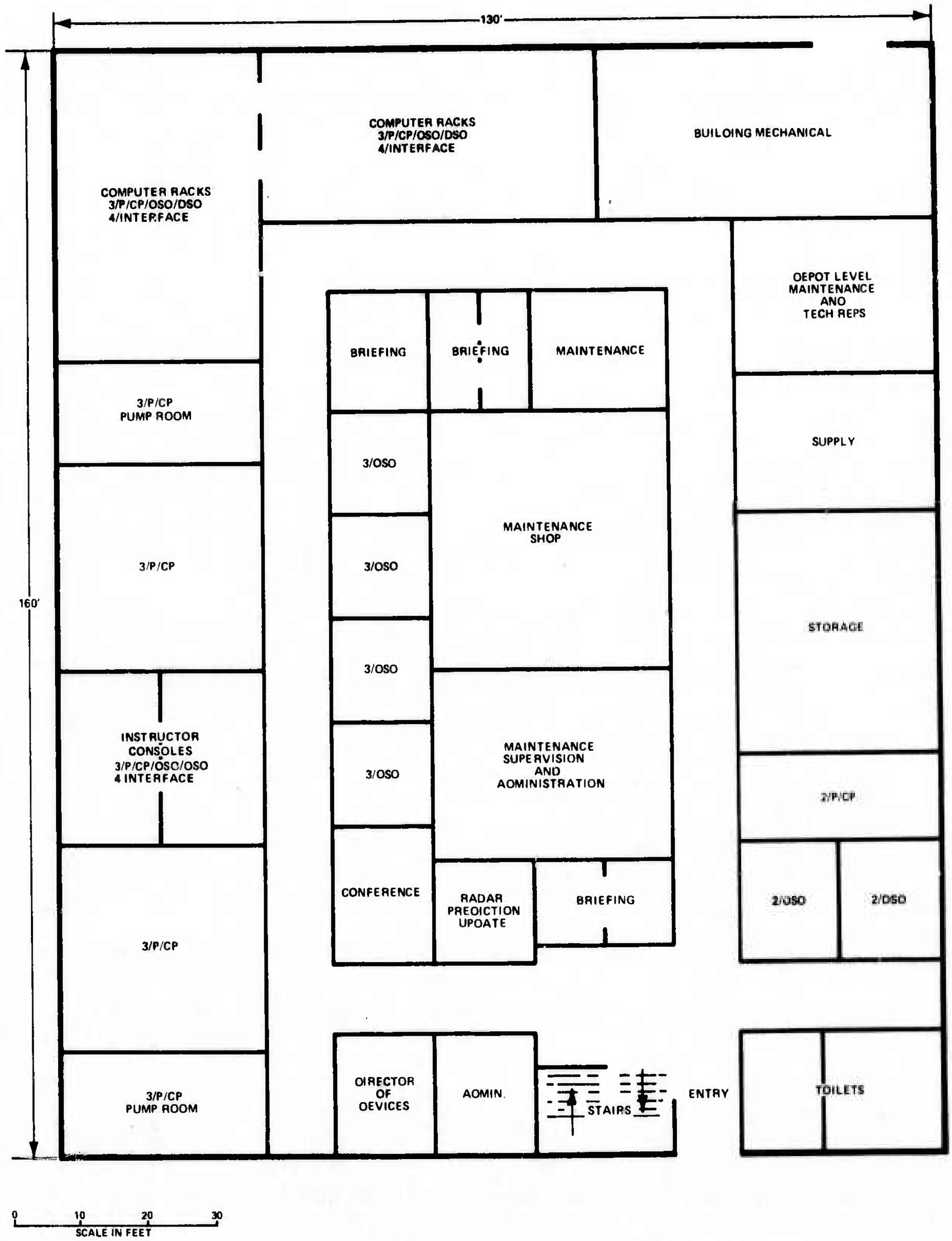

Figure 15 MOB SIMULATOR-TRAINER BUILDING APPROXIMATE AREA 21,000 SQ. FT.

with glass walls that permit visual monitoring of the motion platforms with cockpits.

4.5.3.8 Utilities

Estimated Power Requirements For Devices	Totals
Part-Mission Trainer - Flight Station	
Pumps, platform, cockpit and computers 100 KW per (3 stations)	300 KVA
Part-Mission Trainer - OSO	
Station, landmass and computers 90 KW (3 stations)	270 KVA
Part-Mission Trainer - DSO	
Station, and computers 30 KW (4 stations)	120 KVA
Procedures Trainer	
Stations and mini computers 20 KW (7 stations)	140 KVA

Heating and comfort air conditioning for support areas is to conform with AFM 88-15.

4.5.3.9 Utilization

The devices will be scheduled 5 days for 80 hours a week minimum. Operating time for an additional 16 hour day will be required for make-up and other rescheduling. Maintenance will be performed 6 days a week. Maintenance crews will be on duty 3 shifts per day. Unscheduled work will be performed on devices during training shifts to correct random malfunctions. The third shift will be used for periodic maintenance.

4.5.4 MOB AIRCREW SIMULATOR AND TRAINER BUILDING

At a typical MOB, there will be one set of part-mission trainers, and one full-mission trainer device, each composed of a set of part-mission trainers, i.e. a pilot/copilot (P/CP), offensive systems officer (OSO), and a defensive systems officer (DSO) station. There will also be three procedures trainers, one for each crew position.

The trainers, as shown in the facility layout in Figure 15, are as follows. The familiarization trainers for pilot/copilot are referred to as 2/P/CP, for OSO as 2/OSO, etc. The part-mission training is 3/P/CP, etc. The Full-Mission Trainer is formed by connecting the part-task trainer electronically. The only references in the drawing to the full-mission trainer is in the rack and console rooms where the computers are interfaced, i.e., 4/Interface.

Learning carrels and familiarization trainers may be housed in any operational area such as alert, Squadron Ops., etc. No space has been assigned to these devices in the simulator building.

SPACE REQUIREMENTS

Devices	Number	Space Each	Total SF
Procedures Trainer-P/CP	1	300	300
Procedures Trainer-OSO	1	240	240
Procedures Trainer-DSO	1	240	240
Part-Mission Trainer-P/CP Incl. station, pumps, console and racks	2	1950	3900
Part-Mission Trainer-OSO Incl. station, console and racks	2	825	1650
Part-Mission Trainer-DSO Incl. station, console and racks	2	600	1200
		Subtotal	7530

4.5.4.1 Full-Mission Trainer

When three part-task stations (pilot/copilot, OSO and DSO), Part-Mission Trainers are connected electronically, they make up an integrated crew mission simulator, Full-Mission Trainer. Full-Mission Trainer space is accounted for in the total of the Part-Mission Trainer above.

Support Areas

Briefing Rooms (5)	780
Maintenance and Storage	5100
Administration	800
Predication Update	220
Building Mechanical	1340
Halls, Stairs, Toilets and Walls	5260
Subtotal for Support	13,500
Total Square Footage	21,030

The table below lists the personnel who will operate in this facility during a typical shift.

Areas	No. Required	Personnel per Shift
2/P/CP	1	2
2/OSO	1	1
2/DSO	1	1
3/P/CP	2	4
3/OSO	2	2
3/DSO	2	2
Briefing Rooms	5	14
Maintenance & Supply	6	27
Administration	3	4
Instructors	-	4
Update	1	1
	Total	52

The simulator-trainer building should be adjacent to the alert facility if practical, if not, as close to the alert and other operational areas as possible.

These simulator facilities should be operational at MOBs to phase in as the aircraft arrive.

Construction is to be in accordance with AFM 88-15 standards. Other design considerations follow that of the CCTS aircrew trainer building in particular with respect to:

- o EMI-RFI screening
- o Pump room isolation
- o Computer room floor
- o Air conditioning packages for equipment cooling
- o High bay areas
- o Entrance to pilot/copilot cockpit
- o Heating and air conditioning
- o Console rooms

See the following table for power requirements.

Device	Power for Devices	Totals
1	**Part-Mission Trainers** pumps platform, cockpit commuters and console, 100 KVA (2 each)	200 KVA
2	Part-Mission Trainers station, landmass, computers and console, 90 KVA (2 each)	180 KVA
3	Part-Mission Trainers station, computers and console, 30 KVA (2 each)	60 KVA
4	Procedures Trainer stations and mini computers, 30 KVA 3 each)	60 KVA

This facility must be capable of handling Top Secret SIOP/ESI tapes and other material.

4.5.4.2 Utilization

The facilities will be scheduled 7 days a week and will operate 96 hours a week minimum. Operating time above 96 hours will be required for make-up and other necessary rescheduling. Maintenance will be performed 7 days a week. Maintenance crews will be on duty 3 shifts per day. Maintenance scheduling will be at the convenience of the unit training coordinator.

Section 5

CONCLUDING REMARKS

The SAT process has been followed to provide the B-1 SPO with the recommendations of the previous sections of this report. The preferred instructional system, however, is not complete as described in a number of important ways, nor has the SAT process been carried out in its entirety. The "next steps" that must be taken are discussed in this concluding section in approximately the same order as that in which they should be performed.

1. Development of the DSO Syllabus. A complete task analysis for the Defensive Systems Operator (DSO) was not available in sufficient time to be analyzed as part of this program. Some assumptions were made regarding the likely training resource requirements for the DSO so that a better approximation of the entire aircrew training system could be provided in this report. The first "next step" should obviously be to complete the definition of the DSO syllabus, its training device requirements, and its other resource requirements.

2. Determination of the B-1 Performance Characteristics. As additional experience is gained from the B-1 prototype test flights and as the design specifications of B-1 systems are finalized, information regarding the performance characteristics of the B-1 should be made available to the training analysts who will assume responsibility after this study. Examples of the nature of such data include:

1) acceleration characteristics during normal and emergency maneuvers;
2) operational flight program characteristics for the on-board computers;
3) updates in equipment specifications; and so forth.

The analysts would use that information to refine the functional specifications of the training devices and/or to refine the data in the task analysis and the behavioral objectives, thus filling in a number of entries which are now TBD (to be determined).

3. Completion of the Task Analysis. The task analysis delivered to Calspan for use in this program contained only information for a "perfect" EWO mission. It did not cover tasks related to CONUS airspace regulations, nor, more importantly, did it contain malfunction and emergency task descriptions. These latter tasks were generated from other documents available to the Calspan analysts and incorporated as a Mission Segment 20. In conjunction with Item 2 above, new information will become available to further delineate, refine, and complete the task analysis data base. Further refinements of the B-1 Aircrew Instructional System may then be implemented.

4. Criterion Test Development. Because of the deficiencies noted in Items 2 and 3, it was not possible to complete a specification of the criterion tests to be used to measure attainment of the training (behavioral) objectives. It has been recognized, however, that testing will be an integral, and usually "on-line," part of the training program. This is in keeping with the instructional strategies employed (e.g., individualized instruction, use of computer-managed instruction, early hands-on, student-paced, and so forth). As the TBDs are eliminated from the performance requirements specifications in the behavioral objectives, the criterion performance will then be available for inclusion in the criterion test specifications.

5. Refinement of Input Data. The assumptions used in this program are generally those that are documented in Appendix A to this report (Technical Memorandum SAT-1, Vol. 2). The quality of this data is also indicated along a three-point scale covering the range from "good" to "poor" reliability. The data used were the best available as determined by the analysts, but because data of "low" and "fair" reliability are included, it is recommended that such data are further investigated via whatever means possible to achieve an increase in overall reliability of the estimates generated by the Training Resources Analytic Model (TRAM). An example of such data are the costs associated with the component parts of the various training devices, especially Devices 3 and 4.

6. Further System Analyses. Many factors affect the characteristics of the training system. Those factors are the ones included as input variables to TRAM. The previous section of this report and Appendix A (Technical Memorandum SAT-1, Vol. 2) describes some of the ramifications of alternative structuring of the preferred instructional system. As the total B-1 development program proceeds, many of these factors will become fixed via constraints and/or doctrine, while other factors may take on a new importance (e.g., the current fuel crisis). As an on-going effort, the ramifications of current decisions should be re-examined (using TRAM) in light of new alternatives that become probable or possible for consideration. These include new basing concepts, partial centralization of Proficiency Maintenance Training concepts other than those considered in this report, new training device technology, and unpredicted changes in costs or budgets.

7. Training Device Specifications. Although it is realized that procurement of facilities and training devices must be initiated soon, all of the above items will impact on the final specifications of the recommended training devices. Integration of that information (the above items) should be made the responsibility of those who formulate those specifications. This implies a good working relationship between the several individuals who will be involved in that process, including those who eventually will be responsible for administering the crew member proficiency measures and providing the necessary feedback to the training course development team.

Certain items were left open-ended in the functional descriptions of the training devices (e.g., the use of the on-board computer hardware in the training devices). Closure can only be obtained on such items as new information is gathered from within and without the B-1 Program. Guidance should be taken from the experience of other programs, military and civilian, (in their proper context) along with the discussions in the Simulation Technology Assessment Report (Technical Memorandum SAT-3).

8. Training System Implementation. The finalization of the instructional system design allows the final four-step process to be initiated. Those steps are:

a) development of lesson specifications;
b) production of courseware, software, and hardware;
c) deployment of the instructional system; and,
d) quality control.

<u>Lesson specifications</u> for each course will be derived on the basis of the instructional block sequence (Section 3) and the behavioral objectives (Technical Memorandum SAT-2), plus any updates to either that result from the refinements due to Items 1 to 7 above. The production of the <u>courseware</u> (texts, slides, tapes, etc.) and training devices <u>software</u> and <u>hardware</u> is the obvious next step, which then allows the <u>deployment of the instructional system</u> in the field (preferably following preliminary try-outs on small samples of students). Once the system becomes operational, it is vitally important to establish a <u>quality control</u> program that allows the SAC Headquarters ISD team to detect flaws in any of the components making up the entire instructional system. Feedback of students' performance from all points in their progress (CCTS and MOBs) via the computer-managed-instruction system allows for the ongoing validation of all aspects from the task analysis to the courseware and criterion tests. Many of the applicable techniques are well-known ("item analysis" from the tests and measurements field), while others will depend upon the experience and good judgment of the ISD team (e. g., selection of performance measures to be monitored in the devices or air vehicle). The inclusion of a quality control system and the application of TRAM will make possible the assessment of new or proposed changes to the instructional system. Of particular importance are changes relating to instructional block durations, Proficiency Maintenance training requirements, and the myriad changes brought about by altering the basing structure, crew ratio, and so forth.

The Systems Approach to Training is certainly no panacea for instructional system development. It offers the systems analytic techniques, but cannot compensate for technically poor decisions, cannot induce creativity and innovation into the decision processes, and cannot provide more than a pointer to the research that is yet necessary to provide the stuff from which good decisions can come. Calspan has applied the talents of a highly diversified team to provide a comprehensive analysis of the B-1 aircrew training requirements that may be looked upon as a prototype for future programs. It is believed by the authors that the documentation provided by the reports listed in the Preface approaches the state-of-the-art in the Systems Approach to Training.

This technical memorandum completes all effort on the Systems Approach to Training program.

Section 6

Allocation of Instructional Blocks to Behavioral Objectives According to Track

Table 18, presented on the following pages, indicates the instructional blocks within which the criteria of each Behavioral Objective (Beh.Obj.) are first attained. The listing is according to tracks (see Section 3.4.3) for the Pilot, Copilot, and OSO, plus the Synchronization track in which all crew positions participate. Behavioral Objectives for the DSO were not prepared as part of this program.

Table 18

Allocation of Instructional Blocks to Behavioral Objectives According to Track

Beh. Obj.	Title	Track								
		Pilot			Copilot			OSO		All
		A	B	C	D	E	F	G	H	Sync.
1.1	Post Security Guards	-	-	-	-	-	-	-	-	6
1.2	Perform Exterior Inspection	48	52	55	52	52	-	-	-	-
1.3	Perform Exterior Inspection	-	-	-	-	-	92	106	120	-
1.4	Perform "Power Off" Interior Inspection	-	-	-	-	-	-	-	-	4
1.5	Perform "Power Off" Interior Inspection	-	-	-	-	-	86	100	110	-
1.6	Perform "Power On" Interior Inspection	-	-	-	-	-	-	-	-	4
1.7	Perform "Power On" Interior Inspection	-	-	-	-	-	86	100	110	-
1.8	Perform cocking	-	-	-	-	-	-	-	-	28
1.9	Perform cocking	-	-	-	-	-	-	-	-	28
1.10	Perform daily alert preflight	-	-	-	-	-	-	-	-	13
1.11	Perform daily alert preflight	-	-	-	-	-	-	-	-	13
1.12	Rotate crews	-	-	-	-	-	-	-	-	13
1.13	Rotate crews	-	-	-	-	-	-	-	-	13
2.1	Prepare to enter air vehicle	-	-	-	-	-	-	-	-	13
2.2	Prepare to enter air vehicle	-	-	-	-	-	-	-	-	13
2.3	Enter Crew Stations	48	52	55	52	52	-	-	-	-
2.4	Enter Crew Stations	-	-	-	-	-	92	106	120	-
2.5	Check APU Start Status	27	29	29	29	29	-	-	-	-
2.6	Set Parking Brake	4	4	4	4	4	-	-	-	-
2.7	Perform engine start	27	29	29	29	29	-	-	-	-
2.8	Monitor UHF communications	-	-	-	-	-	-	-	-	4
2.9	Monitor UHF communications	-	-	-	-	-	86	100	110	-
2.10	Restart APU's	27	29	29	29	29	-	-	-	-
2.11	Perform Engine Shutdown	27	29	29	29	29	-	-	-	-
3.1	Pre-taxi operations	40	45	44	45	44	-	-	-	-
3.2	Pre-taxi operations	-	-	-	-	-	20	28	28	-
3.3	Prepare to taxi	40	45	44	45	44	-	-	-	-
3.4	Initiate taxi	52	56	59	56	56	-	-	-	-

Table 18 (Continued)

Beh. Obj.	Title	Track								
		Pilot			Copilot			OSO		All
		A	B	C	D	E	F	G	H	Sync.
3.5	Monitor UHF & Instruments while taxiing	-	-	-	-	-	-	-	-	4
3.6	Secure restraints & remove safety pins	40	45	44	45	44	-	-	-	-
3.7	Steer A/V onto runway	-	-	-	-	-	-	-	-	14
3.8	Execute ground FLR update	-	-	-	-	-	86	100	110	-
4.1	Perform pre T.O. checks	77	85	99	85	86	-	-	-	-
4.2	Perform pre T.O. checks	-	-	-	-	-	32	40	42	-
4.3	Initiate take-off	27	29	29	29	29	-	-	-	-
4.4	Perform take-off	33	35	35	35	35	-	-	-	-
5.1	Initiate climb	27	29	29	29	29	-	-	-	-
5.2	Perform climb	33	35	35	35	35	-	-	-	-
5.3	Climb out	42	47	46	47	46	-	-	-	-
5.4	Climb out	-	-	-	-	-	48	56	61	-
6.1	Perform level-off	42	47	46	47	46	-	-	-	-
6.2	Crew station check	-	-	-	-	-	86	100	110	-
6.3	Crew station check	-	-	-	-	-	-	-	-	4
6.4	Activate functional systems	42	47	46	47	46	-	-	-	-
6.5	Activate functional systems	-	-	-	-	-	18	26	26	-
6.6	Apply power to stores	-	-	-	-	-	86	100	110	-
6.7	Load EWD mission cassette	-	-	-	-	-	71	82	92	-
6.8	Execute FLR update	-	-	-	-	-	73	84	95	-
7.1	Pre-rendezvous procedures	-	-	-	-	-	-	-	-	4
7.2	Pre-rendezvous procedures	-	-	-	-	-	86	100	110	-
7.3	Tanker Identification Procedure	-	-	-	-	-	86	100	110	-
7.4	ARIP descent procedures	-	-	-	-	-	86	100	110	-
7.5	Execute ARIP descent	-	-	-	-	-	-	-	-	4
7.6	Execute pre-ARCP level-off	-	-	-	-	-	-	-	-	4
7.7	Pre-ARCP level-off communication	-	-	-	-	-	86	100	110	-

Table 18 (Continued)

Beh. Obj.	Title	Track								
		Pilot			Copilot			OSO		All
		A	B	C	D	E	F	G	H	Sync.
7.8	Establish AR formation	-	-	-	-	-	-	-	-	4
7.9	Post-ARCP procedures	-	-	-	-	-	86	100	110	-
7.10	Closure on tanker procedures	-	-	-	-	-	-	-	-	4
7.11	Closure on tanker procedures	42	47	40	47	46	-	-	-	-
7.12	Closure on tanker procedures	-	-	-	-	-	86	100	110	-
7.13	Establish pre-contact position	42	47	46	47	46	-	-	-	-
7.14	Pre-contact procedures	-	-	-	-	-	86	100	110	
7.15	Pre-contact procedures	42	47	46	47	46	-	-	-	
7.16	Establish contact position	52	56	59	56	56	-	-	-	-
7.17	Aerial refueling contact procedures	-	-	-	-	-	-	-	-	4
7.18	Execute aerial refueling	52	56	59	56	56	-	-	-	-
7.19	Disconnect procedures	42	47	46	47	46	-	-	-	-
7.20	Post-disconnect maneuver	52	56	59	56	56	-	-	-	-
7.21	Depart tanker	52	56	59	56	56	-	-	-	-
7.22	Initiate climb	27	29	29	29	29	-	-	-	-
7.23	Engage altitude hold & auto throttle	42	47	46	47	46	-	-	-	-
7.24	End aerial refueling	11	11	11	11	11	-	-	-	-
7.25	End aerial refueling	-	-	-	-	-	6	12	12	-
8.1	Decode execution order	-	-	-	-	-	-	-	-	4
8.2	Monitor/Adjust system avionics	-	-	-	-	-	60	71	79	-
8.3	Receive and validate mission order	-	-	-	-	-	-	-	-	4
8.4	Turn on strike course	33	35	35	35	35	-	-	-	-
8.5	HHCL entry procedures	40	45	99	45	77	-	-	-	-
8.6	HHCL entry procedures	-	-	-	-	-	6	12	12	-
8.7	Perform Nuclear PA/Consent Procedure	-	-	-	-	-	71	82	92	-
8.8	Perform Nuclear PA/Consent Procedure	80	92	106	92	94	-	-	-	-
8.9	Initiate Weapons Monitoring	-	-	-	-	-	88	102	113	-
9.1	Establish Supersonic Flight	82	94	111	94	96	-	-	-	-
9.2	Perform Supersonic Climb	82	94	111	94	96	-	-	-	-

Table 18 (Continued)

Beh. Obj.	Title	Track								
		Pilot			Copilot			OSO		All
		A	B	C	D	E	F	G	H	Sync.
9.3	Level-off supersonically	82	94	111	94	96	-	-	-	-
9.4	Engage auto pilot and altitude hold	82	94	111	94	96	-	-	-	-
9.5	Execute FLR update	-	-	-	-	-	86	100	110	-
9.6	Execute attitude calibration	-	-	-	-	-	73	84	95	-
9.7	Perform IP acquisition	-	-	-	-	-	48	51	61	-
9.8	Perform gravity store pre-release	80	92	106	92	94	-	-	-	-
9.9	Perform gravity store pre-release	-	-	-	-	-	77	88	99	-
9.10	Perform bomb run tracking	-	-	-	-	-	48	56	61	-
9.11	Set FLR for gravity store release	-	-	-	-	-	27	35	35	-
9.12	Perform gravity store release	80	92	106	92	94	-	-	-	-
9.13	Perform gravity store release	-	-	-	-	-	77	88	99	-
9.14	Bomb run altitude change	-	-	-	-	-	-	-	-	8
10.1	Perform TF operational procedures	82	94	111	94	96	-	-	-	-
10.2	Execute TF operation checks	82	94	111	94	96	-	-	-	-
10.3	Complete pre-descent to low level	-	-	-	-	-	6	12	12	-
10.4	Complete pre-descent to low level	82	94	111	94	96	-	-	-	-
10.5	Perform pre-descent to low level checks	-	-	-	-	-	-	-	-	14
10.6	Initiate descent	70	79	88	79	80	-	-	-	-
10.7	Perform descent	70	79	88	79	80	-	-	-	-
10.8	Turn to initial check point	82	84	111	94	96	-	-	-	-
10.9	Turn to initial check point	-	-	-	-	-	60	71	79	-
10.10	Perform pre-level-off at TF altitude	82	84	111	94	96	-	-	-	-
10.11	Level-off at TF altitude	-	-	-	-	-	45	53	58	-
10.12	Level-off at TF altitude	82	84	111	94	96	-	-	-	-
10.13	Execute altitude calibration	-	-	-	-	-	73	92	103	
11.1	Select TF modes for ATF	-	-	-	-	-	-	-	-	14
11.2	Complete AFCS and TFR checks	70	79	88	79	80	-	-	-	-
11.3	Low level cruise (ATF)	82	94	111	94	96	-	-	-	-
11.4	Monitor TF modes for ATF	-	-	-	-	-	73	92	103	-

Table 18 (Continued)

Beh. Obj.	Title	Track								
		Pilot			Copilot			OSO		All
		A	B	C	D	E	F	G	H	Sync.
11.5	Monitor displays for ATF	-	-	-	-	-	-	-	-	14
11.6	Change to MTF	58	63	69	63	63	-	-	-	-
11.7	Low level cruise (MTF)	82	94	111	94	96	-	-	-	-
11.8	Monitor display for MTF	70	79	88	79	80	-	-	-	-
11.9	Determine lateral course deviation	82	94	111	94	96	-	-	-	-
11.10	Determine lateral course deviation	-	-	-	-	-	73	92	103	-
11.11	Maneuver A/V at low level	82	94	111	94	96	-	-	-	-
11.12	Monitor lateral course deviation	-	-	-	-	-	-	-	-	14
11.13	Engage AFCS for ATF	70	79	88	79	80	-	-	-	-
11.14	Perform EVS update	-	-	-	-	-	-	-	-	14
11.15	Perform EVS update	-	-	-	-	-	-	-	-	14
11.16	Execute FLR update	-	-	-	-	-	86	100	110	-
11.17	Execute altitude calibration	-	-	-	-	-	73	92	103	-
12.1	Perform BDA operations	-	-	-	-	-	-	-	-	14
12.2	Perform BDA operations	-	-	-	-	-	-	-	-	14
12.3	Perform SRAM initialization	80	92	106	92	94	-	-	-	-
12.4	Perform SRAM initialization	-	-	-	-	-	83	97	108	-
12.5	Perform SRAM pre-launch operation	-	-	-	-	-	-	-	-	8
12.6	Perform SRAM pre-launch operation	82	94	111	94	96	-	-	-	-
12.7	Perform SRAM pre-launch procedures	-	-	-	-	-	-	-	-	8
12.8	Perform SRAM launch operations	-	-	-	-	-	-	-	-	8
12.9	Perform SRAM launch operations	-	-	-	-	-	-	-	-	8
12.10	Perform gravity store pre-release	-	-	-	-	-	83	97	108	-
12.11	Perform gravity store pre-release	80	92	106	92	94	-	-	-	-
12.12	Perform bomb run tracking	-	-	-	-	-	-	-	-	19
12.13	Perform gravity store release	-	-	-	-	-	-	-	-	19
12.14	Perform gravity store release	-	-	-	-	-	-	-	-	19
13.1	Terminate TF procedures	58	63	69	63	63	-	-	-	-
13.2	Terminate TF operations	82	94	111	94	96	-	-	-	-

Table 18 (Continued)

Beh. Obj.	Title	Track								
		Pilot			Copilot			OSO		All
		A	B	C	D	E	F	G	H	Sync.
13.3	Establish subsonic cruise operation	42	47	46	47	46	-	-	-	-
13.4	Establish subsonic cruise procedures	42	47	46	47	46	-	-	-	-
13.5	Assemble strike report information	-	-	-	-	-	83	97	108	-
13.6	Transmit strike report	-	-	-	-	-	-	-	-	4
14.1	Review penetration procedures	27	29	29	29	29	-	-	-	-
14.2	Perform pre-descent procedures	27	29	29	29	29	-	-	-	-
14.3	Perform pre-descent procedures	-	-	-	-	-	86	100	110	-
14.4	Configure flight station for descent proced.	27	29	29	29	29	-	-	-	-
14.5	Configure flight station for descent checks	70	79	88	79	80	-	-	-	-
14.6	Configure flight station for descent proced.	-	-	-	-	-	-	-	-	14
14.7	Execute descent	42	47	46	47	46	-	-	-	-
14.8	Crosscheck altimeters	14	14	14	14	14	-	-	-	-
14.9	Perform descent procedures	-	-	-	-	-	86	100	110	-
14.10	Configure for landing approach	42	47	46	47	46	-	-	-	-
14.11	Verify magnetic variation	-	-	-	-	-	22	30	30	-
15.1	Perform before landing checks	27	29	29	29	29	-	-	-	-
15.2	Perform pre-AILA operations	33	35	35	35	35	-	-	-	-
15.3	Perform pre-AILA operations	-	-	-	-	-	86	100	110	-
15.4	Perform automatic AILA	42	47	46	47	46	-	-	-	-
15.5	Acquire runway visually	27	29	29	29	29	-	-	-	-
15.6	Perform touchdown	52	56	59	56	56	-	-	-	-
15.7	Decelerate on landing roll	52	56	59	56	56	-	-	-	-
15.8	After landing checks	27	29	29	29	29	-	-	-	-
15.9	After landing checks	-	-	-	-	-	20	28	28	-
15.10	Taxi and park air vehicle	52	56	59	56	56	-	-	-	-
15.11	Flight station shut down	27	29	29	29	29	-	-	-	-
15.12	Avionics station shut down	-	-	-	-	-	-	-	-	4
15.13	Start L/APU	27	29	29	29	29	-	-	-	-
15.14	Perform engine shutdown	27	29	29	29	29	-	-	-	-

Table 18 (Continued)

Beh. Obj.	Title	Track								
		Pilot			Copilot			OSO		All
		A	B	C	D	E	F	G	H	Sync.
15.15	Pre-exit procedures	-	-	-	-	-	92	106	120	-
16.1	Configure A/V ground refuel for refuel	29	31	31	31	31	-	-	-	-
16.2	Determine fuel quantity on board	29	31	31	31	31	-	-	-	-
16.3	Select fuel quantity to be up loaded	29	31	31	31	31	-	-	-	-
16.4	Monitor fuel flow into A/V	29	31	31	31	31	-	-	-	-
16.5	Configure A/V ground refuel panel to terminate refueling	29	31	31	31	31	-	-	-	-
16.6	Verify fuel on A/V	29	31	31	31	31	-	-	-	-
16.7	Secure A/V after refueling operation	29	31	31	31	31	-	-	-	-
16.8	Verify A/V status	51	55	58	55	55	-	-	-	-
16.9	Perform walk around inspection	51	55	58	55	55	-	-	-	-
16.10	Perform walk around inspection	-	-	-	-	-	90	106	120	-
Emergency Procedures										
20.1	Perform Internal Engine Fire Procedures	33	35	35	35	35	-	-	-	-
20.2	Perform Nacelle Fire - Engine Procedures	33	35	35	35	35	-	-	-	-
20.3	Perform Nacelle Fire - APU Procedures	33	35	35	35	35	-	-	-	-
20.4	Perform Fire Detection System Failure Procedures	25	27	27	27	27	-	-	-	-
20.5	Perform Emergency Air Vehicle Braking	27	29	29	29	29	-	-	-	-
20.6	Abandon Air Vehicle on Ground	48	52	55	52	52	92	106	120	-
20.7	Abort Take-Off	42	47	46	47	46	-	-	-	-
20.8	Abort Take-Off - Engine Failure	42	47	46	47	46	-	-	-	-
20.9	Continue Take-Off - Engine Failure	42	47	46	47	46	-	-	-	-
20.10	Abort Take-Off - Engine Fire	42	47	46	47	46	-	-	-	-
20.11	Continue Take-Off - Engine Fire	42	47	46	47	46	-	-	-	-

Table 18 (Continued)

Beh. Obj.	Title	Track								
		Pilot			Copilot			OSO		All
		A	B	C	D	E	F	G	H	Sync.
20.12	Perform Loss of Crew Compartment Pressure Procedures	70	79	88	79	80	84	98	112	-
20.13	Perform Cabin Overheat Procedures	70	79	88	79	80	84	98	112	-
20.14	Perform Cabin Too Cold Procedures	70	79	88	79	80	84	98	112	-
20.15	Perform Avionics Compartment Overheat Procedures	70	79	88	79	80	84	98	112	-
20.16	Perform Smoke or Fumes in Crew Compartment Procedures	70	79	88	79	80	84	98	112	-
20.17	Perform Before Ejection Procedures	44	49	48	49	48	92	106	120	-
20.18	Perform Ejection	44	49	48	49	48	92	106	120	-
20.19	Perform Throttle System Malfunction Procedures	27	29	29	29	29	-	-	-	-
20.20	Perform Engine Failure (Non-Mechanical) During Flight Procedures	42	47	46	47	46	-	-	-	-
20.21	Perform Engine Failure (Mechanical) During Flight Procedures	42	47	46	47	46	-	-	-	-
20.22	Perform Unassisted (Windmilling) Airstart	42	47	46	47	46	-	-	-	-
20.23	Perform APU-Assisted Airstart	42	47	46	47	46	-	-	-	-
20.24	Perform Engine Stall Procedures	42	47	46	47	46	-	-	-	-
20.25	Perform Engine Fire During Flight Procedures	42	47	46	47	46	-	-	-	-
20.26	Perform APU Fire During Flight Procedures	42	47	46	47	46	-	-	-	-
20.27	Perform Low Oil Pressure/Quantity Procedures	42	47	46	47	46	-	-	-	-
20.28	Perform Excessive Engine Vibration Procedures	42	47	46	47	46	-	-	-	-
20.29	Perform Fuel Tanks 1 & 4 Will Not Transfer to Main Tanks Procedures	33	35	35	35	35	-	-	-	-
20.30	Perform Fuel Cooling Loop Return Failure Procedures	33	35	35	35	35	-	-	-	-
20.31	Perform Fuel Cooling Loop Crossover Failure Procedures	33	35	35	35	35	-	-	-	-
20.32	Perform Fuel Cooling Loop Ram Airscoop System Failure Procedures	33	35	35	35	35	-	-	-	-

Table 18 (Continued)

Beh. Obj.	Title	Track								
		Pilot			Copilot			OSO		All
		A	B	C	D	E	F	G	H	Sync.
20.33	Perform Fuel System Operation During Emergency Generator Operation	33	35	35	35	35	-	-	-	-
20.34	Perform Single Generator Failure Procedures	60	65	71	65	65	-	-	-	-
20.35	Perform Double Generator Failure Procedures	60	65	71	65	65	-	-	-	-
20.36	Perform Triple Generator Failure Procedures	60	65	71	65	65	-	-	-	-
20.37	Perform Single Bus Tie Failure Procedures	60	65	71	65	65	-	-	-	-
20.38	Perform Both Bus Tie Failure Procedures	60	65	71	65	65	-	-	-	-
20.39	Perform Bus Failure Procedures	60	65	71	65	65	-	-	-	-
20.40	Perform Complete Loss of Electrical Power Procedures	60	65	71	65	65	-	-	-	-
20.41	Perform Hydraulic Pressure & Quantity Failure Procedures	27	29	29	29	29	-	-	-	-
20.42	Perform Loss of Hydraulic Systems 2,3 and 4 Procedures	27	29	29	29	29	-	-	-	-
20.43	Perform SMES Failure Procedures	82	94	111	94	96	-	-	-	-
20.44	Perform Pitch Trim Normal System Failure Procedures	42	47	46	47	46	-	-	-	-
20.45	Perform Wing Sweep Runaway In Aft Direction Procedures	82	94	111	94	96	-	-	-	-
20.46	Perform Wing Sweep Runaway In Forward Direction Procedures	82	94	111	94	96	-	-	-	-
20.47	Perform Wing Will Not Maintain Forward Sweep Procedures	82	94	111	94	96	-	-	-	-
20.48	Perform Landing With Three-Engines - Inoperative	82	94	111	94	96	-	-	-	-
20.49	Perform Landing-Gear Malfunction Procedures	27	29	29	29	29	-	-	-	-
20.50	Perform Landing With Any Gear Retracted or Unlocked	82	94	111	94	96	-	-	-	-
20.51	Perform Nosewheel Steering System Failure Procedures	82	94	111	94	96	-	-	-	-

Table 18 (Continued)

Beh. Obj.	Title	Track								
		Pilot			Copilot			OSO		All
		A	B	C	D	E	F	G	H	Sync.
20.52	Perform Antiskid System Failure Procedures	82	94	111	94	96	-	-	-	-
20.53	Perform Nose Gear Tire Failure Landing	82	94	111	94	96	-	-	-	-
20.54	Perform Main Gear Tire Failure Landing	82	94	111	94	96	-	-	-	-
20.55	Perform Belly Landing	82	94	111	94	96	92	106	120	-
20.56	Perform Ditching of the Air Vehicle	82	94	111	94	96	92	106	120	-

SECTION 7

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